



Version 4.1

DOCUMENTATION REPORT

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GLOSSARY

Add-On Control Device: An air pollution control device such as carbon absorber or incinerator that reduces the pollution in exhaust gas. The control device usually does not affect the process being controlled and thus is "add-on" technology, as opposed to a scheme to control pollution through altering the basic process itself.

Best Available Control Technology (BACT): An emission limitation based on the maximum degree of reduction of each pollutant subject to regulation under the Clean Air Act emitted from or which results from any major emitting facility, which the permitting authority, on a case-by-case basis, taking into account energy, environmental, and economic impacts and other costs, determines is achievable for such facility through application of production processes and available methods, systems, and techniques, including fuel cleaning, clean fuels, or treatment or innovative fuel combustion techniques for control of each such pollutant.

Best Available Retrofit Control Technology (BARCT): An air emission limitation that applies to existing sources and is based on the maximum degree of reduction achievable, taking into account environmental, energy, and economic impacts by each class or category of source.

Case: For a given source category in AirControlNET, if there are more than one control measure for controlling a given pollutant, then each control measure is assigned a case number and is treated as a separate case from the others in the model.

Capital Recovery Factor (CRF): A function of the economic life of the equipment and the interest rate charged to the total capital investment.

Capital to Annual Ratio: Ratio of Capital costs to annual costs.

Cost-Effectiveness (C-E): The cost of an emission control measure assessed in terms of dollars-per-pound, or dollars-per-ton, of air emissions reduced.

Control Efficiency: The percent of pollutant mass reduced from the application of a control measure.

Control Technique Guidelines (CTGs): An EPA guidance document which triggers a responsibility under section 182(b)(2) for States to submit reasonably available control technology (RACT) rules for stationary sources of VOC as part of their State Implementation Plans.

Control Technology; Control Measures: Equipment, processes or actions used to reduce air pollution. The extent of pollution reduction varies among technologies and measures.

Criteria Air Pollutant: A pollutant designated by the Administrator, using the latest scientific knowledge, to have effects on public health or welfare which may be expected from the presence of such pollutant in the ambient air, in varying quantities. The types of air pollutants

which, when present in the atmosphere, may interact with such pollutant to produce an adverse effect on public health or welfare; and any known or anticipated adverse effects on welfare.

Cyclone boiler: means a boiler with one or more water-cooled horizontal cylindrical chambers in which coal combustion takes place. The horizontal cylindrical chamber(s) is (are) attached to the bottom of the furnace. One or more cylindrical chambers are arranged either on one furnace wall or on two opposed furnace walls. Gaseous combustion products exiting from the chamber(s) turn 90 degrees to go up through the boiler while coal ash exits the bottom of the boiler as a molten slag.

Dry bottom: means the boiler has a furnace bottom temperature below the ash melting point and the bottom ash is removed as a solid.

Emission inventory: means a listing of the quantity of pollutants being emitted from sources within a geographic boundary (i.e., country, State, nation). The listing can be broken down into point (individual facilities), area (other stationary sources), mobile (on-road and non-road), and biogenic emissions. Ancillary information such as stack parameters, activity data, and vehicle type are also considered part of an emission inventory.

Emission Rate: The weight of a pollutant emitted per unit of time (e.g., tons/year).

Federal Implementation Plan (FIP): In the absence of an approved State Implementation Plan (SIP), a plan prepared by EPA which provides measures that nonattainment areas must take to meet the requirements of the Federal Clean Air Act.

Inspection and Maintenance Program (I/M program): A periodic automobile inspection, usually done once a year or once every two years to check whether a car is being maintained to keep pollution down and whether emission control systems are working properly. Vehicles which do not pass inspection must be repaired.

Lifetime: The estimated years add-on control equipment will operated before it must be replaced.

Maximum Achievable Control Technology (MACT): Federal emissions limitations based on the best demonstrated control technology or practices in similar sources to be applied to major sources emitting one or more federal HAP.

MEAS Code: An alphanumeric code assigned to each individual control measure in the AirControlNET Model. These are unique and used internally by Pechan.

New Source Performance Standards (NSPS): Uniform national EPA air emission standards that limit the amount of pollution allowed from new sources or from modified existing sources.

Operating and Maintenance Costs (O&M): The costs associated with work and materials needed to preserve asset components to allow their continued use. This definition encompasses any actions intended to prevent failure or inefficient operation, and includes housekeeping and

custodial work. Operating Maintenance does not necessarily prolong the design service life of the property of equipment, nor does it add to the asset's value. However, lack of maintenance can reduce an asset's value by leading to equipment breakdown, premature failure of a building's subsystems and shortening of the asset's useful service lifetime.

Reasonably Available Control Technology (RACT): Defined as the lowest emission limitation that a particular source is capable of meeting by the application of control technology that is reasonably available, considering technological and economic feasibility.

Rule Effectiveness: a generic term for identifying and estimating the uncertainties in emission estimates caused by failures and uncertainties in emission control programs. Literally, it is the extent to which a rule achieves the desired emission reductions.

Source Category: Categories of places or objects from which air pollutants are released. Sources that are fixed in space are stationary sources and sources that move or are capable of moving are mobile sources. See Area, Mobile and Stationary.

- Area sources--means stationary and non-road sources that are too numerous or whose emissions are too small to be individually included in a stationary source emissions inventory.
- Mobile sources--means on-road (highway) vehicles (e.g., automobiles, trucks and motorcycles) and non-road vehicles and engines (e.g., trains, airplanes, agricultural equipment, industrial equipment, construction vehicles, off-road motorcycles, and marine vessels).
- Point Sources: Specific points of origin where pollutants are emitted into the atmosphere from stationary sources such as factory smokestacks.
- Stationary Sources: Non-mobile sources such as power plants, refineries, and manufacturing facilities which emit air pollutants.

State Implementation Plan (SIP): A plan prepared by States and submitted to EPA describing how each area will attain and maintain national ambient air quality standards. SIPs include the technical foundation for understanding the air quality (e.g. emission inventories and air quality monitoring), control measures and strategies, and enforcement mechanisms.

Stoker boiler: means a boiler that burns solid fuel in a bed, on a stationary or moving grate, that is located at the bottom of the furnace.

Tangentially fired boiler: means a boiler that has coal and air nozzles mounted in each corner of the furnace where the vertical furnace walls meet. Both pulverized coal and air are directed from the furnace corners along a line tangential to a circle lying in a horizontal plane of the furnace.

Transportation Control Measure (TCM): Any control measure to reduce vehicle trips, vehicle use, vehicle miles traveled, vehicle idling, or traffic congestion for the purpose of reducing on-

road motor vehicle emissions. TCMs can include encouraging the use of carpools and mass transit.

Wall-fired boiler: means a boiler that has pulverized coal burners arranged on the walls of the furnace. The burners have discrete, individual flames that extend perpendicularly into the furnace area.

Wet bottom: means that the ash is removed from the furnace in a molten state. The term “wet bottom boiler” shall include: wet bottom wall-fired boilers, including wet bottom turbo-fired boilers; and wet bottom boilers otherwise meeting the definition of vertically fired boilers, including wet bottom arch-fired boilers, wet bottom roof-fired boilers, and wet bottom top-fired boilers. The term “wet bottom boiler” shall exclude cyclone boilers and tangentially fired boilers.

CHAPTER I. INTRODUCTION

AirControlNET is a control technology analysis tool developed by E.H. Pechan & Associates, Inc. (Pechan) to support the U.S. Environmental Protection Agency (EPA) in its analyses of air pollution policies and regulations. The tool provides data on emission sources, potential pollution control measures and emission reductions, and the costs of implementing those controls.

The core of AirControlNET is a relational database system in which control technologies are linked to sources within EPA emissions inventories. The system contains a database of control measure applicability, efficiency, and cost information for reducing the emissions contributing to ambient concentrations of ozone, PM₁₀, PM_{2.5}, SO₂, NO₂, as well as visibility impairment (regional haze) from point, area, and mobile sources. PM₁₀ and PM_{2.5} as included in AirControlNET represent primary emissions of PM. The control measure data file in AirControlNET includes not only the technology's control efficiency, and calculated emission reductions for that source, but also estimates the costs (annual and capital) for application of the control measure.

This document describes the control technology and cost information that is used to create the control measure database. The AirControlNET User's Guide and Development Report provide details of the installation, system requirements, use of the AirControlNET interface, and control measure database development (Pechan, 2005a and Pechan, 2005b).

AirControlNET relies on the control efficiency, throughput, fuel use, and emission factor data provided in the NEI to perform cost related analysis. But AirControlNET also requires information about individual control measures. This information is obtained by examining the technical and economic data available on the control measures. AirControlNET currently contains information on several hundred different control measure/source combinations.

Pechan has collected information on control measure and reported it to the EPA through several technical reports. Important aspects of each control measure, such as application, functionality, cost and control efficiencies were reported at the time of analysis. The purpose of this document is to compile and summarize this information for the control measures presently available in AirControlNET to provide a central location of the information.

Individual control measures are discussed in this report under the Control Measure Documentation chapter (Chapter III). Some of the important aspects of analysis used for these control measures are summarized in the Summary section of this report. Table I-1 provides a list of AirControlNET related publications prepared by Pechan. The References section contains complete citations.

Table I-1. List of Related Publications Prepared by Pechan and EPA that Contain Useful Control Measure Information

Publication Name	Publication Date	Comments
AirControlNET User's Guide	03/2005	Learn how to install and use AirControlNET
AirControlNET Tool Development Kit	03/2005	Learn how the AirControlNET application and control measure databases were developed
VOC and NO _x Control Measures Adopted by States and Nonattainment Areas for 1999 NEI Base Case Emissions Projection Calculations, Pechan Report No. 02.09.002/9010.122	09/2002	Contains information on local controls adopted through ozone SIPs
Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analysis, Pechan Report No. 01.09.9010.007	09/2001	Control measure research and evaluations
Control Measure Development Support Analysis of Ozone Transport Commission Model Rules, Pechan Report No. 01.02.001/9408.000	02/2001	Control measure research and evaluations
EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC.	01/2002	Control measure research and evaluations
Control Measure Evaluations: The Control Measure Data Base for the National Emissions Trends Inventory (AirControlNET), by E.H. Pechan & Associates, Pechan Report No. 99.09.001/9004.112	09/1999	Control measure research and evaluations
Control Measure Evaluations Prepared for South Central and Reading-Lehigh Valley Pennsylvania Ozone Stakeholders Groups - Report," prepared for Pennsylvania Department of Environmental Protection, Bureau of Air Quality, Harrisburg, PA, by E.H. Pechan & Associates	12/1999	Control measure research and evaluations
Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, NC, prepared by E.H. Pechan & Associates, Inc., September 1998	09/1998	Control measure research and evaluations
Control Measure Evaluation for the Integrated Implementation of the Ozone and particulate Matter National Ambient Air Quality Standards and Regional Haze Program, Pechan Report No. 97.03.001/1800 (Rev.)	04/1997	Control measure research and evaluations

Table I-1 (continued)

Publication Name	Publication Date	Comments
Additional Control Measure Evaluation for The Integrated Implementation of the Ozone and Particulate Matter National Ambient Air Quality Standards, and Regional Haze Program, Pechan Report No. 97.03.001/1800 (Rev.)	03/1997	Control measure research and evaluations
Regional Particulate Strategies, Pechan Report No. 95.09.0005/1754	09/1995	Control measure research and evaluations
Analysis of Incremental Emission Reductions and Costs of VOC and NO _x Control Measures, prepared for U.S. Environmental Protection Agency, Ambient Standards Branch, Research Triangle Park, NC, prepared by E.H. Pechan & Associates, Inc., September 1994.	09/1994	Control measure research and evaluations

Additionally, three appendices are included to provide helpful summary information. Appendix A provides a control measure summary list sorted by source category. Appendix B provides a control measure summary list sorted by pollutant. Appendix C provides a SCC-SIC-NAICS Crosswalk.

CHAPTER II. SUMMARY

The control measure data needed to generate the costs and emission reductions for measures in AirControlNET include throughput, fuel use, and emission factor data provided in EPA emission inventories such as the National Emissions Inventory (NEI).

AirControlNET's database system links control measures to pollution sources identified in EPA point, area, and mobile source emissions inventories. The resulting database of control measures contains information on each measure, including emission reduction, control efficiency, and cost information. Control measures are included for emissions contributing to ambient concentrations of ozone, PM_{2.5}, PM₁₀, SO₂, and NO₂, as well as visibility impairment (regional haze). The control measure data in AirControlNET includes not only the measure's control efficiency and calculated emission reduction for that source, but also estimates the costs (annual and capital, and sometimes O&M) for application of the control measure.

In determining the costs for each control measure, AirControlNET links basic cost information from EPA and other studies to input parameters contained in the emission inventory. Currently, AirControlNET contains several hundred source category and pollutant-specific control measures. Table II-1 provides a summary of the number of control measures that are presently in AirControlNET.

Table II-1. Number of Control Measures in AirControlNET, by Sector and Pollutant

Major Pollutant	Utility	Non-Utility	Area	Onroad	Nonroad	Total
NH ₃	0	0	3	0	0	3
NO _x	26	417	15	15	8	481
PM	24	165	12	13	0	214
SO ₂	6	37	0	0	0	43
VOC	0	7	65	5	12	89
Hg	5	0	0	0	0	5

The control measures in AirControlNET have been developed through a series of studies prepared to support rulemakings or research. Important elements that are identified for each control measure. These elements are discussed below and summarized for each measure in the at-a-glance tables in Chapter III of this report. Some of the important factors that have been studied are:

Pollutants: AirControlNET contains a database of control measures and cost information for emissions contributing to ambient concentrations of ozone, PM_{2.5}, PM₁₀, SO₂, and NO₂, as well as visibility impairment (regional haze). Presently this system includes controls for NO_x, SO₂, VOC, PM₁₀, PM_{2.5}, Hg and NH₃. PM₁₀ and PM_{2.5} as included in AirControlNET represent primary emissions of PM.

Sector: AirControlNET relies heavily upon EPA emission inventory data as a source of emissions. The control measures from utility, point, area, and mobile source sector emissions

Sector: AirControlNET relies heavily upon EPA emission inventory data as a source of emissions. The control measures from utility, point, area, and mobile source sector emissions inventories are supplied in EPA's National Emission Inventory (NEI) can be used in creating overall emission reduction scenarios in which the associated costs can be estimated.

Control Efficiencies: The control measure data file in AirControlNET includes the technology's control efficiency. The control measure's control efficiency sometimes reflects a set of baseline conditions that are elaborated upon in the at-a-glance tables in Chapter III of the report, where appropriate.

Cost Information: The cost information in AirControlNET may have many components including annual, capital, and operation & maintenance costs for application of the control measure. The individual control measure reference documents discuss the source of the cost information. Other components include capital recovery factor and dollar year of cost estimate (i.e., \$1997).

Base Year of Cost: The cost information for the control measures have been compiled through a series of analyses performed by EPA and others over several years. In every case, the costs for control measure is estimated in the base year provided by the original study. AirControlNET converts to consistent year dollars.

POD: The cost POD is an internal field which groups together similar source types. We can think of them as a group of sources similar enough that a specific control measure can be applied to all SCCs in the group.

Affected SCC: The Source Classification Code, or the SCC, in combination with the POD are what link the control measure information to the NEI data. This linkage is essential for AirControlNET functions which allow the user to create various cost related scenarios based on the selected control measures applied to specific sources of emission.

Rule Effectiveness: Rule effectiveness is the assumption of how effective a rule containing a control measure would be. Rule effectiveness is generally 80 to 100 percent for point source rules and potentially less for area source or mobile source rules.

Rule Penetration: Rule Penetration is the assumed fraction of the targeted SCC which are affected by the control measure. It is generally assumed 100 percent for point sources, but can be less for area or mobile sources.

Measure Code: The control measures codes are unique codes assigned by E.H. Pechan & Associates that specify control measure and source type combination. Each measure in Chapter III of this report is identified by an alphanumeric measure code or a "meas code". The first character of the code is a letter that corresponds to the major pollutant controlled.

Typical Value: The typical value often referred to in this report is the value used in AirControlNET. The value has been determined to be the "best" value for a measure of interest

(e.g. control efficiency). The typical value can be, but is not necessarily, a statistical measure of central tendency.

Table II-2 provides a list of the control measures and sources documented in this report.

To obtain further information on AirControlNET, please contact:

EPA Contact: Larry Sorrels at sorrels.larry@epamail.epa.gov

E.H. Pechan Contact: Frank Divita at fdivita@pechan.com

Table II-2. Control Measures Included in AirControlNET

Measure Code	Source Category	Major Pollutant	Control Measure
A00101	Cattle Feedlots	NH3	Chemical Additives to Waste
A00201	Poultry Operations	NH3	Chemical Additives to Waste
A00301	Hog Operations	NH3	Chemical Additives to Waste
AT2010	Off-Highway Vehicles: All Terrain Vehicles (ATVs)	VOC	2010 Implementation of Recreational Gasoline ATV Standards
AT2015	Off-Highway Vehicles: All Terrain Vehicles (ATVs)	VOC	2015 Implementation of Recreational Gasoline ATV Standards
AT2020	Off-Highway Vehicles: All Terrain Vehicles (ATVs)	VOC	2020 Implementation of Recreational Gasoline ATV Standards
AT2030	Off-Highway Vehicles: All Terrain Vehicles (ATVs)	VOC	2030 Implementation of Recreational Gasoline ATV Standards
CI2010	Off-Highway Diesel Vehicles	NOX	2010 Implementation of Final Compression-Ignition (C-I) Engine Standards
CI2015	Off-Highway Diesel Vehicles	NOX	2015 Implementation of Final Compression-Ignition (C-I) Engine Standards
CI2020	Off-Highway Diesel Vehicles	NOX	2020 Implementation of Final Compression-Ignition (C-I) Engine Standards
CI2030	Off-Highway Diesel Vehicles	NOX	2030 Implementation of Final Compression-Ignition (C-I) Engine Standards
HDD10	Highway Vehicles - Heavy Duty and Diesel-Fueled Vehicles	NOX	2010 Implementation of Heavy Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur C
HDD15	Highway Vehicles - Heavy Duty and Diesel-Fueled Vehicles	NOX	2015 Implementation of Heavy Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur C
HDD20	Highway Vehicles - Heavy Duty and Diesel-Fueled Vehicles	NOX	2020 Implementation of Heavy Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur C
HDD30	Highway Vehicles - Heavy Duty and Diesel-Fueled Vehicles	NOX	2030 Implementation of Heavy Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur C
HDR101	Highway Vehicles - Heavy Duty Diesel Engines	PM	Voluntary Diesel Retrofit Program: Diesel Particulate Filter - 2001
HDR110	Highway Vehicles - Heavy Duty Diesel Engines	PM	Voluntary Diesel Retrofit Program: Diesel Particulate Filter - 2010
HDR115	Highway Vehicles - Heavy Duty Diesel Engines	PM	Voluntary Diesel Retrofit Program: Diesel Particulate Filter - 2015
HDR199	Highway Vehicles - Heavy Duty Diesel Engines	PM	Voluntary Diesel Retrofit Program: Diesel Particulate Filter - 1999
HDR201	Highway Vehicles - Heavy Duty Diesel Engines	PM	Voluntary Diesel Retrofit Program: Diesel Oxidation Catalyst - 2001
HDR210	Highway Vehicles - Heavy Duty Diesel Engines	PM	Voluntary Diesel Retrofit Program: Diesel Oxidation Catalyst - 2010
HDR215	Highway Vehicles - Heavy Duty Diesel Engines	PM	Voluntary Diesel Retrofit Program: Diesel Oxidation Catalyst - 2015
HDR299	Highway Vehicles - Heavy Duty Diesel Engines	PM	Voluntary Diesel Retrofit Program: Diesel Oxidation Catalyst - 1999
HDR301	Highway Vehicles - Heavy Duty Diesel Engines	NOX	Voluntary Diesel Retrofit Program: Selective Catalytic Reduction - 2001
HDR310	Highway Vehicles - Heavy Duty Diesel Engines	NOX	Voluntary Diesel Retrofit Program: Selective Catalytic Reduction - 2010
HDR315	Highway Vehicles - Heavy Duty Diesel Engines	NOX	Voluntary Diesel Retrofit Program: Selective Catalytic Reduction - 2015
HDR399	Highway Vehicles - Heavy Duty Diesel Engines	NOX	Voluntary Diesel Retrofit Program: Selective Catalytic Reduction - 1999
HDR401	Highway Vehicles - Heavy Duty Diesel Engines	PM	Voluntary Diesel Retrofit Program: Biodiesel Fuel - 2001

Table II-2 (continued)

Measure Code	Source Category	Major Pollutant	Control Measure
HDR410	Highway Vehicles - Heavy Duty Diesel Engines	PM	Voluntary Diesel Retrofit Program: Biodiesel Fuel - 2010
HDR415	Highway Vehicles - Heavy Duty Diesel Engines	PM	Voluntary Diesel Retrofit Program: Biodiesel Fuel - 2015
HDR499	Highway Vehicles - Heavy Duty Diesel Engines	PM	Voluntary Diesel Retrofit Program: Biodiesel Fuel - 1999
MC2010	Off-Highway Vehicles: Motorcycles	VOC	2010 Implementation of Recreational Gasoline Off-Highway Motorcycle Standards
MC2015	Off-Highway Vehicles: Motorcycles	VOC	2015 Implementation of Off-Highway Motorcycle Standards
MC2020	Off-Highway Vehicles: Motorcycles	VOC	2020 Implementation of Off-Highway Motorcycle Standards
MC2030	Off-Highway Vehicles: Motorcycles	VOC	2030 Implementation of Off-Highway Motorcycle Standards
N00101	Utility Boiler - Coal/Wall	NOX	Selective Non-Catalytic Reduction (SNCR)
N00102	Utility Boiler - Coal/Wall	NOX	Natural Gas Reburn (NGR)
N00103	Utility Boiler - Coal/Wall	NOX	Selective Catalytic Reduction (SCR)
N00201	Utility Boiler - Coal/Tangential	NOX	Selective Non-Catalytic Reduction (SNCR)
N00202	Utility Boiler - Coal/Tangential	NOX	Natural Gas Reburn (NGR)
N00203	Utility Boiler - Coal/Tangential	NOX	Selective Catalytic Reduction (SCR)
N00501	Utility Boiler - Oil-Gas/Wall	NOX	Selective Non-Catalytic Reduction (SNCR)
N00502	Utility Boiler - Oil-Gas/Wall	NOX	Natural Gas Reburn (NGR)
N00503	Utility Boiler - Oil-Gas/Wall	NOX	Selective Catalytic Reduction (SCR)
N00601	Utility Boiler - Oil-Gas/Tangential	NOX	Selective Non-Catalytic Reduction (SNCR)
N00602	Utility Boiler - Oil-Gas/Tangential	NOX	Natural Gas Reburn (NGR)
N00603	Utility Boiler - Oil-Gas/Tangential	NOX	Selective Catalytic Reduction (SCR)
N00701	Utility Boiler - Cyclone	NOX	Selective Non-Catalytic Reduction (SNCR)
N00702	Utility Boiler - Cyclone	NOX	Natural Gas Reburn (NGR)
N00703	Utility Boiler - Cyclone	NOX	Selective Catalytic Reduction (SCR)
N00801	Coal-fired Plants with Production Capacities > 100MW	NOX	Combustion Optimization
N00901	Utility Boiler - Coal/Wall	NOX	Low NOx Burner
N00902	Utility Boiler - Coal/Wall	NOX	Low NOx Burner with Overfire Air
N00903	Utility Boiler - Coal/Tangential	NOX	Low NOx Coal-and-Air Nozzles with Close-Coupled Overfire Air
N00904	Utility Boiler - Coal/Tangential	NOX	Low NOx Coal-and-Air Nozzles with Separated Overfire Air
N00905	Utility Boiler - Coal/Tangential	NOX	Low NOx Coal-and-Air Nozzles with Close-Coupled and Separated Overfire Air
N00906	Utility Boiler - Coal/Wall	NOX	Low NOx Burner
N00907	Utility Boiler - Coal/Wall	NOX	Low NOx Burner with Overfire Air
N00908	Utility Boiler - Coal/Tangential	NOX	Low NOx Coal-and-Air Nozzles with Close-Coupled Overfire Air
N00909	Utility Boiler - Coal/Tangential	NOX	Low NOx Coal-and-Air Nozzles with Separated Overfire Air
N00910	Utility Boiler - Coal/Tangential	NOX	Low NOx Coal-and-Air Nozzles with Close-Coupled and Separated Overfire Air
N01101	ICI Boilers - Coal/Wall	NOX	Selective Non-Catalytic Reduction (SNCR)
N01103	ICI Boilers - Coal/Wall	NOX	Low NOx Burner
N01104	ICI Boilers - Coal/Wall	NOX	Selective Catalytic Reduction (SCR)
N0111L	ICI Boilers - Coal/Wall - Large	NOX	Selective Non-Catalytic Reduction (SNCR)
N0111S	ICI Boilers - Coal/Wall	NOX	Selective Non-Catalytic Reduction (SNCR)
N0113L	ICI Boilers - Coal/Wall - Large	NOX	Low NOx Burner
N0113S	ICI Boilers - Coal/Wall	NOX	Low NOx Burner
N0114L	ICI Boilers - Coal/Wall - Large	NOX	Selective Catalytic Reduction (SCR)
N0114S	ICI Boilers - Coal/Wall	NOX	Selective Catalytic Reduction (SCR)

Table II-2 (continued)

Measure Code	Source Category	Major Pollutant	Control Measure
N01201	ICI Boilers - Coal/FBC	NOX	Selective Non-Catalytic Reduction (SNCR) Urea Based
N0121L	ICI Boilers - Coal/FBC - Large Sources	NOX	Selective Non-Catalytic Reduction (SNCR) Urea Based
N0121S	ICI Boilers - Coal/FBC	NOX	Selective Non-Catalytic Reduction (SNCR) Urea Based
N01301	ICI Boilers - Coal/Stoker	NOX	Selective Non-Catalytic Reduction (SNCR)
N0131L	ICI Boilers - Coal/Stoker - Large	NOX	Selective Non-Catalytic Reduction (SNCR)
N0131S	ICI Boilers - Coal/Stoker	NOX	Selective Non-Catalytic Reduction (SNCR)
N01401	ICI Boilers - Coal/Cyclone	NOX	Selective Non-Catalytic Reduction (SNCR)
N01402	ICI Boilers - Coal/Cyclone	NOX	Coal Reburn
N01403	ICI Boilers - Coal/Cyclone	NOX	Selective Catalytic Reduction (SCR)
N01404	ICI Boilers - Coal/Cyclone	NOX	Natural Gas Reburn (NGR)
N0141S	ICI Boilers - Coal/Cyclone	NOX	Selective Non-Catalytic Reduction (SNCR)
N0142L	ICI Boilers - Coal/Cyclone - Large Sources	NOX	Coal Reburn
N0142S	ICI Boilers - Coal/Cyclone	NOX	Coal Reburn
N0143S	ICI Boilers - Coal/Cyclone	NOX	Selective Catalytic Reduction (SCR)
N0144S	ICI Boilers - Coal/Cyclone	NOX	Natural Gas Reburn (NGR)
N01501	ICI Boilers - Residual Oil	NOX	Low NOx Burner
N01502	ICI Boilers - Residual Oil	NOX	Low NOx Burner + Flue Gas Recirculation
N01503	ICI Boilers - Residual Oil	NOX	Selective Catalytic Reduction (SCR)
N01504	ICI Boilers - Residual Oil	NOX	Selective Non-Catalytic Reduction (SNCR)
N0151S	ICI Boilers - Residual Oil	NOX	Low NOx Burner
N0152S	ICI Boilers - Residual Oil	NOX	Low NOx Burner + Flue Gas Recirculation
N0153S	ICI Boilers - Residual Oil	NOX	Selective Catalytic Reduction (SCR)
N0154L	ICI Boilers - Residual Oil - Large Sources	NOX	Selective Non-Catalytic Reduction (SNCR)
N0154S	ICI Boilers - Residual Oil	NOX	Selective Non-Catalytic Reduction (SNCR)
N01601	ICI Boilers - Distillate Oil	NOX	Low NOx Burner
N01602	ICI Boilers - Distillate Oil	NOX	Low NOx Burner + Flue Gas Recirculation
N01603	ICI Boilers - Distillate Oil	NOX	Selective Catalytic Reduction (SCR)
N01604	ICI Boilers - Distillate Oil	NOX	Selective Non-Catalytic Reduction (SNCR)
N0161S	ICI Boilers - Distillate Oil	NOX	Low NOx Burner
N0162S	ICI Boilers - Distillate Oil	NOX	Low NOx Burner + Flue Gas Recirculation
N0163S	ICI Boilers - Distillate Oil	NOX	Selective Catalytic Reduction (SCR)
N0164S	ICI Boilers - Distillate Oil	NOX	Selective Non-Catalytic Reduction (SNCR)
N01701	ICI Boilers - Natural Gas	NOX	Low NOx Burner
N01702	ICI Boilers - Natural Gas	NOX	Low NOx Burner + Flue Gas Recirculation
N01703	ICI Boilers - Natural Gas	NOX	Oxygen Trim + Water Injection
N01704	ICI Boilers - Natural Gas	NOX	Selective Catalytic Reduction (SCR)
N01705	ICI Boilers - Natural Gas	NOX	Selective Non-Catalytic Reduction (SNCR)
N0171S	ICI Boilers - Natural Gas	NOX	Low NOx Burner
N0172S	ICI Boilers - Natural Gas	NOX	Low NOx Burner + Flue Gas Recirculation
N0173S	ICI Boilers - Natural Gas	NOX	Oxygen Trim + Water Injection
N0174S	ICI Boilers - Natural Gas	NOX	Selective Catalytic Reduction (SCR)
N0175L	ICI Boilers - Natural Gas - Large Sources	NOX	Selective Non-Catalytic Reduction (SNCR)
N0175S	ICI Boilers - Natural Gas	NOX	Selective Non-Catalytic Reduction (SNCR)
N01801	ICI Boilers - Wood/Bark/Stoker	NOX	Selective Non-Catalytic Reduction (SNCR) Urea Based
N0181L	ICI Boilers - Wood/Bark/Stoker - Large Sources	NOX	Selective Non-Catalytic Reduction (SNCR) Urea Based
N0181S	ICI Boilers - Wood/Bark/Stoker	NOX	Selective Non-Catalytic Reduction (SNCR) Urea Based
N02001	ICI Boilers - MSW/Stoker	NOX	Selective Non-Catalytic Reduction (SNCR) Urea Based
N0201S	ICI Boilers - MSW/Stoker	NOX	Selective Non-Catalytic Reduction (SNCR) Urea Based

Table II-2 (continued)

Measure Code	Source Category	Major Pollutant	Control Measure
N02101	Internal Combustion Engines - Oil	NOX	Ignition Retard
N02104	Internal Combustion Engines - Oil	NOX	Selective Catalytic Reduction (SCR)
N02105	Rich Burn Internal Combustion Engines - Oil	NOX	Non-Selective Catalytic Reduction (NSCR)
N0211S	Internal Combustion Engines - Oil	NOX	Ignition Retard
N0214S	Internal Combustion Engines - Oil	NOX	Selective Catalytic Reduction (SCR)
N0215S	Rich Burn Internal Combustion Engines - Oil	NOX	Non-Selective Catalytic Reduction (NSCR)
N02201	Internal Combustion Engines - Gas	NOX	L-E (Medium Speed)
N02204	Internal Combustion Engines - Gas	NOX	Air/Fuel Ratio Adjustment
N02207	Internal Combustion Engines - Gas	NOX	Air/Fuel + Ignition Retard
N02210	Internal Combustion Engines - Gas	NOX	L-E (Medium Speed)
N02211	IC Engines - Gas	NOX	L-E (Low Speed)
N02212	IC Engines - Gas	NOX	Selective Catalytic Reduction (SCR)
N02213	Rich Burn IC Engines - Gas	NOX	Non-Selective Catalytic Reduction (NSCR)
N0221L	Internal Combustion Engines - Gas	NOX	Ignition Retard
N0221S	Internal Combustion Engines - Gas	NOX	Ignition Retard
N0224L	Internal Combustion Engines - Gas - Large	NOX	Air/Fuel Ratio Adjustment
N0224S	Internal Combustion Engines - Gas	NOX	Air/Fuel Ratio Adjustment
N0227L	Internal Combustion Engines - Gas - Large	NOX	Air/Fuel + Ignition Retard
N0227S	Internal Combustion Engines - Gas	NOX	Air/Fuel + Ignition Retard
N02301	Combustion Turbines - Oil	NOX	Water Injection
N02302	Combustion Turbines - Oil	NOX	Selective Catalytic Reduction (SCR) + Water Injection
N0231S	Combustion Turbines - Oil	NOX	Water Injection
N0232S	Combustion Turbines - Oil	NOX	Selective Catalytic Reduction (SCR) + Water Injection
N02401	Combustion Turbines - Natural Gas	NOX	Water Injection
N02402	Combustion Turbines - Natural Gas	NOX	Steam Injection
N02403	Combustion Turbines - Natural Gas	NOX	Dry Low NOx Combustor
N02404	Combustion Turbines - Natural Gas	NOX	Selective Catalytic Reduction (SCR) + Low NOx Burner (LNB)
N02405	Combustion Turbines - Natural Gas	NOX	Selective Catalytic Reduction (SCR) + Steam Injection
N02406	Combustion Turbines - Natural Gas	NOX	Selective Catalytic Reduction (SCR) + Water Injection
N0241S	Combustion Turbines - Natural Gas	NOX	Water Injection
N0242S	Combustion Turbines - Natural Gas	NOX	Steam Injection
N0243L	Combustion Turbines - Natural Gas - Large Sources	NOX	Dry Low NOx Combustors
N0243S	Combustion Turbines - Natural Gas	NOX	Dry Low NOx Combustors
N0244S	Combustion Turbines - Natural Gas	NOX	Selective Catalytic Reduction (SCR) + Low NOx Burner (LNB)
N0245S	Combustion Turbines - Natural Gas	NOX	Selective Catalytic Reduction (SCR) + Steam Injection
N0246S	Combustion Turbines - Natural Gas	NOX	Selective Catalytic Reduction (SCR) + Water Injection
N02501	Process Heaters - Distillate Oil	NOX	Low NOx Burner
N02502	Process Heaters - Distillate Oil	NOX	Low NOx Burner + Flue Gas Recirculation
N02503	Process Heaters - Distillate Oil	NOX	Selective Non-Catalytic Reduction (SNCR)
N02504	Process Heaters - Distillate Oil	NOX	Ultra Low NOx Burner
N02505	Process Heaters - Distillate Oil	NOX	Selective Catalytic Reduction (SCR)
N02506	Process Heaters - Distillate Oil	NOX	Low NOx Burner - Selective Non-Catalytic Reduction (SNCR)

Table II-2 (continued)

Measure Code	Source Category	Major Pollutant	Control Measure
N02507	Process Heaters - Distillate Oil	NOX	Low NOx Burner (LNB) + Selective Catalytic Reduction (SCR)
N0251S	Process Heaters - Distillate Oil	NOX	Low NOx Burner
N0252S	Process Heaters - Distillate Oil	NOX	Low NOx Burner + Flue Gas Recirculation
N0253S	Process Heaters - Distillate Oil	NOX	Selective Non-Catalytic Reduction (SNCR)
N0254S	Process Heaters - Distillate Oil	NOX	Ultra Low NOx Burner
N0255S	Process Heaters - Distillate Oil	NOX	Selective Catalytic Reduction (SCR)
N0256S	Process Heaters - Distillate Oil	NOX	Low NOx Burner - Selective Non-Catalytic Reduction (SNCR)
N0257S	Process Heaters - Distillate Oil	NOX	Low NOx Burner (LNB) + Selective Catalytic Reduction (SCR)
N02601	Process Heaters - Residual Oil	NOX	Low NOx Burner + Flue Gas Recirculation
N02602	Process Heaters - Residual Oil	NOX	Low NOx Burner
N02603	Process Heaters - Residual Oil	NOX	Selective Non-Catalytic Reduction (SNCR)
N02604	Process Heaters - Residual Oil	NOX	Ultra Low NOx Burner
N02605	Process Heaters - Residual Oil	NOX	Low NOx Burner - Selective Non-Catalytic Reduction (SNCR)
N02606	Process Heaters - Residual Oil	NOX	Selective Catalytic Reduction (SCR)
N02607	Process Heaters - Residual Oil	NOX	Low NOx Burner (LNB) + Selective Catalytic Reduction (SCR)
N0261S	Process Heaters - Residual Oil	NOX	Low NOx Burner + Flue Gas Recirculation
N0262S	Process Heaters - Residual Oil	NOX	Low NOx Burner
N0263S	Process Heaters - Residual Oil	NOX	Selective Non-Catalytic Reduction (SNCR)
N0264S	Process Heaters - Residual Oil	NOX	Ultra Low NOx Burner
N0265S	Process Heaters - Residual Oil	NOX	Low NOx Burner - Selective Non-Catalytic Reduction (SNCR)
N0266S	Process Heaters - Residual Oil	NOX	Selective Catalytic Reduction (SCR)
N0267S	Process Heaters - Residual Oil	NOX	Low NOx Burner (LNB) + Selective Catalytic Reduction (SCR)
N02701	Process Heaters - Natural Gas	NOX	Low NOx Burner
N02702	Process Heaters - Natural Gas	NOX	Low NOx Burner + Flue Gas Recirculation
N02703	Process Heaters - Natural Gas	NOX	Selective Non-Catalytic Reduction (SNCR)
N02704	Process Heaters - Natural Gas	NOX	Ultra Low NOx Burner
N02705	Process Heaters - Natural Gas	NOX	Selective Catalytic Reduction (SCR)
N02706	Process Heaters - Natural Gas	NOX	Low NOx Burner - Selective Non-Catalytic Reduction (SNCR)
N02707	Process Heaters - Natural Gas	NOX	Low NOx Burner (LNB) + Selective Catalytic Reduction (SCR)
N0271S	Process Heaters - Natural Gas	NOX	Low NOx Burner
N0272S	Process Heaters - Natural Gas	NOX	Low NOx Burner + Flue Gas Recirculation
N0273S	Process Heaters - Natural Gas	NOX	Selective Non-Catalytic Reduction (SNCR)
N0274S	Process Heaters - Natural Gas	NOX	Ultra Low NOx Burner
N0275S	Process Heaters - Natural Gas	NOX	Selective Catalytic Reduction (SCR)
N0276S	Process Heaters - Natural Gas	NOX	Low NOx Burner - Selective Non-Catalytic Reduction (SNCR)
N0277S	Process Heaters - Natural Gas	NOX	Low NOx Burner (LNB) + Selective Catalytic Reduction (SCR)
N02901	Nitric Acid Manufacturing	NOX	Extended Absorption
N02902	Nitric Acid Manufacturing	NOX	Selective Catalytic Reduction (SCR)
N02903	Nitric Acid Manufacturing	NOX	Selective Non-Catalytic Reduction (SNCR)
N0291S	Nitric Acid Manufacturing	NOX	Extended Absorption
N0292S	Nitric Acid Manufacturing	NOX	Selective Catalytic Reduction (SCR)
N0293S	Nitric Acid Manufacturing	NOX	Selective Non-Catalytic Reduction (SNCR)
N03001	Glass Manufacturing - Containers	NOX	Electric Boost
N03002	Glass Manufacturing - Containers	NOX	Cullet Preheat
N03003	Glass Manufacturing - Containers	NOX	Low NOx Burner
N03004	Glass Manufacturing - Containers	NOX	Selective Non-Catalytic Reduction (SNCR)

Table II-2 (continued)

Measure Code	Source Category	Major Pollutant	Control Measure
N03005	Glass Manufacturing - Containers	NOX	Selective Catalytic Reduction (SCR)
N03006	Glass Manufacturing - Containers	NOX	OXY-Firing
N0301S	Glass Manufacturing - Containers	NOX	Electric Boost
N0302S	Glass Manufacturing - Containers	NOX	Cullet Preheat
N0303S	Glass Manufacturing - Containers	NOX	Low NOx Burner
N0304S	Glass Manufacturing - Containers	NOX	Selective Non-Catalytic Reduction (SNCR)
N0305S	Glass Manufacturing - Containers	NOX	Selective Catalytic Reduction (SCR)
N0306S	Glass Manufacturing - Containers	NOX	OXY-Firing
N03101	Glass Manufacturing - Flat	NOX	Electric Boost
N03102	Glass Manufacturing - Flat	NOX	Low NOx Burner
N03103	Glass Manufacturing - Flat	NOX	Selective Non-Catalytic Reduction (SNCR)
N03104	Glass Manufacturing - Flat	NOX	Selective Catalytic Reduction (SCR)
N03105	Glass Manufacturing - Flat	NOX	OXY-Firing
N0311L	Glass Manufacturing - Flat - Large	NOX	Electric Boost
N0311S	Glass Manufacturing - Flat	NOX	Electric Boost
N0312L	Glass Manufacturing - Flat	NOX	Low NOx Burner
N0312S	Glass Manufacturing - Flat	NOX	Low NOx Burner
N0313L	Glass Manufacturing - Flat	NOX	Selective Non-Catalytic Reduction (SNCR)
N0313S	Glass Manufacturing - Flat	NOX	Selective Non-Catalytic Reduction (SNCR)
N0314L	Glass Manufacturing - Flat	NOX	Selective Catalytic Reduction (SCR)
N0314S	Glass Manufacturing - Flat	NOX	Selective Catalytic Reduction (SCR)
N0315L	Glass Manufacturing - Flat - Large	NOX	OXY-Firing
N0315S	Glass Manufacturing - Flat	NOX	OXY-Firing
N03201	Glass Manufacturing - Pressed	NOX	Electric Boost
N03202	Glass Manufacturing - Pressed	NOX	Cullet Preheat
N03203	Glass Manufacturing - Pressed	NOX	Low NOx Burner
N03204	Glass Manufacturing - Pressed	NOX	Selective Non-Catalytic Reduction (SNCR)
N03205	Glass Manufacturing - Pressed	NOX	Selective Catalytic Reduction (SCR)
N03206	Glass Manufacturing - Pressed	NOX	OXY-Firing
N0321S	Glass Manufacturing - Pressed	NOX	Electric Boost
N0322S	Glass Manufacturing - Pressed	NOX	Cullet Preheat
N0323S	Glass Manufacturing - Pressed	NOX	Low NOx Burner
N0324S	Glass Manufacturing - Pressed	NOX	Selective Non-Catalytic Reduction (SNCR)
N0325S	Glass Manufacturing - Pressed	NOX	Selective Catalytic Reduction (SCR)
N0326S	Glass Manufacturing - Pressed	NOX	OXY-Firing
N03301	Cement Manufacturing - Dry	NOX	Mid-Kiln Firing
N03302	Cement Manufacturing - Dry	NOX	Low NOx Burner
N03303	Cement Manufacturing - Dry	NOX	Selective Non-Catalytic Reduction (SNCR) Ammonia Based
N03304	Cement Manufacturing - Dry	NOX	Selective Non-Catalytic Reduction (SNCR) Ammonia Based
N03305	Cement Manufacturing - Dry	NOX	Selective Catalytic Reduction (SCR)
N0331L	Cement Manufacturing - Dry	NOX	Mid-Kiln Firing
N0331S	Cement Manufacturing - Dry	NOX	Mid-Kiln Firing
N0332S	Cement Manufacturing - Dry	NOX	Low NOx Burner
N0333S	Cement Manufacturing - Dry	NOX	Selective Non-Catalytic Reduction (SNCR) Urea Based
N0334S	Cement Manufacturing - Dry	NOX	Selective Non-Catalytic Reduction (SNCR) Ammonia Based
N0335S	Cement Manufacturing - Dry	NOX	Selective Catalytic Reduction (SCR)
N03401	Cement Manufacturing - Wet	NOX	Mid-Kiln Firing
N03402	Cement Manufacturing - Wet	NOX	Low NOx Burner
N03403	Cement Manufacturing - Wet	NOX	Selective Catalytic Reduction (SCR)
N0341L	Cement Manufacturing - Wet	NOX	Mid-Kiln Firing
N0341S	Cement Manufacturing - Wet	NOX	Mid-Kiln Firing
N0342L	Cement Manufacturing - Wet	NOX	Low NOx Burner
N0342S	Cement Manufacturing - Wet	NOX	Low NOx Burner

Table II-2 (continued)

Measure Code	Source Category	Major Pollutant	Control Measure
N0343L	Cement Manufacturing - Wet	NOX	Selective Catalytic Reduction (SCR)
N0343S	Cement Manufacturing - Wet	NOX	Selective Catalytic Reduction (SCR)
N03501	Iron & Steel Mills - Reheating	NOX	Low Excess Air (LEA)
N03502	Iron & Steel Mills - Reheating	NOX	Low NOx Burner
N03503	Iron & Steel Mills - Reheating	NOX	Low NOx Burner + Flue Gas Recirculation
N0351S	Iron & Steel Mills - Reheating	NOX	Low Excess Air (LEA)
N0352S	Iron & Steel Mills - Reheating	NOX	Low NOx Burner
N0353S	Iron & Steel Mills - Reheating	NOX	Low NOx Burner + Flue Gas Recirculation
N03601	Iron & Steel Mills - Annealing	NOX	Low NOx Burner
N03602	Iron & Steel Mills - Annealing	NOX	Low NOx Burner + Flue Gas Recirculation
N03603	Iron & Steel Mills - Annealing	NOX	Selective Non-Catalytic Reduction (SNCR)
N03604	Iron & Steel Mills - Annealing	NOX	Low NOx Burner - Selective Non-Catalytic Reduction (SNCR)
N03605	Iron & Steel Mills - Annealing	NOX	Selective Catalytic Reduction (SCR)
N03606	Iron & Steel Mills - Annealing	NOX	Low NOx Burner (LNB) + Selective Catalytic Reduction (SCR)
N0361S	Iron & Steel Mills - Annealing	NOX	Low NOx Burner
N0362S	Iron & Steel Mills - Annealing	NOX	Low NOx Burner + Flue Gas Recirculation
N0363S	Iron & Steel Mills - Annealing	NOX	Selective Non-Catalytic Reduction (SNCR)
N0364S	Iron & Steel Mills - Annealing	NOX	Low NOx Burner - Selective Non-Catalytic Reduction (SNCR)
N0365S	Iron & Steel Mills - Annealing	NOX	Selective Catalytic Reduction (SCR)
N0366S	Iron & Steel Mills - Annealing	NOX	Low NOx Burner (LNB) + Selective Catalytic Reduction (SCR)
N03701	Iron & Steel Mills - Galvanizing	NOX	Low NOx Burner
N03702	Iron & Steel Mills - Galvanizing	NOX	Low NOx Burner + Flue Gas Recirculation
N0371S	Iron & Steel Mills - Galvanizing	NOX	Low NOx Burner
N0372S	Iron & Steel Mills - Galvanizing	NOX	Low NOx Burner + Flue Gas Recirculation
N03801	Municipal Waste Combustors	NOX	Selective Non-Catalytic Reduction (SNCR)
N0381S	Municipal Waste Combustors	NOX	Selective Non-Catalytic Reduction (SNCR)
N03901	Medical Waste Incinerators	NOX	Selective Non-Catalytic Reduction (SNCR)
N0391S	Medical Waste Incinerators	NOX	Selective Non-Catalytic Reduction (SNCR)
N04101	ICI Boilers - Process Gas	NOX	Low NOx Burner
N04102	ICI Boilers - Process Gas	NOX	Low NOx Burner + Flue Gas Recirculation
N04103	ICI Boilers - Process Gas	NOX	Oxygen Trim + Water Injection
N04104	ICI Boilers - Process Gas	NOX	Selective Catalytic Reduction (SCR)
N0411S	ICI Boilers - Process Gas	NOX	Low NOx Burner
N0412S	ICI Boilers - Process Gas	NOX	Low NOx Burner + Flue Gas Recirculation
N0413S	ICI Boilers - Process Gas	NOX	Oxygen Trim + Water Injection
N0414S	ICI Boilers - Process Gas	NOX	Selective Catalytic Reduction (SCR)
N04201	ICI Boilers - Coke	NOX	Selective Non-Catalytic Reduction (SNCR)
N04203	ICI Boilers - Coke	NOX	Low NOx Burner
N04204	ICI Boilers - Coke	NOX	Selective Catalytic Reduction (SCR)
N0421S	ICI Boilers - Coke	NOX	Selective Non-Catalytic Reduction (SNCR)
N0423S	ICI Boilers - Coke	NOX	Low NOx Burner
N0424S	ICI Boilers - Coke	NOX	Selective Catalytic Reduction (SCR)
N04301	ICI Boilers - LPG	NOX	Low NOx Burner
N04302	ICI Boilers - LPG	NOX	Low NOx Burner + Flue Gas Recirculation
N04303	ICI Boilers - LPG	NOX	Selective Catalytic Reduction (SCR)
N04304	ICI Boilers - LPG	NOX	Selective Non-Catalytic Reduction (SNCR)
N0431S	ICI Boilers - LPG	NOX	Low NOx Burner
N0432S	ICI Boilers - LPG	NOX	Low NOx Burner + Flue Gas Recirculation
N0433S	ICI Boilers - LPG	NOX	Selective Catalytic Reduction (SCR)
N0434S	ICI Boilers - LPG	NOX	Selective Non-Catalytic Reduction (SNCR)
N04501	ICI Boilers - Liquid Waste	NOX	Low NOx Burner
N04502	ICI Boilers - Liquid Waste	NOX	Low NOx Burner + Flue Gas Recirculation
N04503	ICI Boilers - Liquid Waste	NOX	Selective Catalytic Reduction (SCR)

Table II-2 (continued)

Measure Code	Source Category	Major Pollutant	Control Measure
N04504	ICI Boilers - Liquid Waste	NOX	Selective Non-Catalytic Reduction (SNCR)
N0451S	ICI Boilers - Liquid Waste	NOX	Low NOx Burner
N0452S	ICI Boilers - Liquid Waste	NOX	Low NOx Burner + Flue Gas Recirculation
N0453S	ICI Boilers - Liquid Waste	NOX	Selective Catalytic Reduction (SCR)
N0454L	ICI Boilers - Distillate Oil - Large Sources	NOX	Selective Non-Catalytic Reduction (SNCR)
N0454S	ICI Boilers - Liquid Waste	NOX	Selective Non-Catalytic Reduction (SNCR)
N04601	IC Engines - Gas, Diesel, LPG	NOX	Ignition Retard
N04604	IC Engines - Gas, Diesel, LPG	NOX	Selective Catalytic Reduction (SCR)
N04605	Rich Burn IC Engines - Gas, Diesel, LPG	NOX	Non-Selective Catalytic Reduction (NSCR)
N0461S	IC Engines - Gas, Diesel, LPG	NOX	Ignition Retard
N0464S	IC Engines - Gas, Diesel, LPG	NOX	Selective Catalytic Reduction (SCR)
N0465S	Rich Burn IC Engines - Gas, Diesel, LPG	NOX	Non-Selective Catalytic Reduction (NSCR)
N04701	Process Heaters - Process Gas	NOX	Low NOx Burner
N04702	Process Heaters - Process Gas	NOX	Low NOx Burner + Flue Gas Recirculation
N04703	Process Heaters - Process Gas	NOX	Selective Non-Catalytic Reduction (SNCR)
N04704	Process Heaters - Process Gas	NOX	Ultra Low NOx Burner
N04705	Process Heaters - Process Gas	NOX	Selective Catalytic Reduction (SCR)
N04706	Process Heaters - Process Gas	NOX	Low NOx Burner - Selective Non-Catalytic Reduction (SNCR)
N04707	Process Heaters - Process Gas	NOX	Low NOx Burner (LNB) + Selective Catalytic Reduction (SCR)
N0471S	Process Heaters - Process Gas	NOX	Low NOx Burner
N0472S	Process Heaters - Process Gas	NOX	Low NOx Burner + Flue Gas Recirculation
N0473S	Process Heaters - Process Gas	NOX	Selective Non-Catalytic Reduction (SNCR)
N0474S	Process Heaters - Process Gas	NOX	Ultra Low NOx Burner
N0475S	Process Heaters - Process Gas	NOX	Selective Catalytic Reduction (SCR)
N0476S	Process Heaters - Process Gas	NOX	Low NOx Burner - Selective Non-Catalytic Reduction (SNCR)
N0477S	Process Heaters - Process Gas	NOX	Low NOx Burner (LNB) + Selective Catalytic Reduction (SCR)
N04801	Process Heaters - LPG	NOX	Low NOx Burner
N04802	Process Heaters - LPG	NOX	Low NOx Burner + Flue Gas Recirculation
N04803	Process Heaters - LPG	NOX	Selective Non-Catalytic Reduction (SNCR)
N04804	Process Heaters - LPG	NOX	Ultra Low NOx Burner
N04805	Process Heaters - LPG	NOX	Selective Catalytic Reduction (SCR)
N04806	Process Heaters - LPG	NOX	Low NOx Burner - Selective Non-Catalytic Reduction (SNCR)
N04807	Process Heaters - LPG	NOX	Low NOx Burner (LNB) + Selective Catalytic Reduction (SCR)
N0481S	Process Heaters - LPG	NOX	Low NOx Burner
N0482S	Process Heaters - LPG	NOX	Low NOx Burner + Flue Gas Recirculation
N0483S	Process Heaters - LPG	NOX	Selective Non-Catalytic Reduction (SNCR)
N0484S	Process Heaters - LPG	NOX	Ultra Low NOx Burner
N0485S	Process Heaters - LPG	NOX	Selective Catalytic Reduction (SCR)
N0486S	Process Heaters - LPG	NOX	Low NOx Burner - Selective Non-Catalytic Reduction (SNCR)
N0487S	Process Heaters - LPG	NOX	Low NOx Burner (LNB) + Selective Catalytic Reduction (SCR)
N04901	Process Heaters - Other Fuel	NOX	Low NOx Burner + Flue Gas Recirculation
N04902	Process Heaters - Other Fuel	NOX	Low NOx Burner
N04903	Process Heaters - Other Fuel	NOX	Selective Non-Catalytic Reduction (SNCR)
N04904	Process Heaters - Other Fuel	NOX	Ultra Low NOx Burner
N04905	Process Heaters - Other Fuel	NOX	Low NOx Burner - Selective Non-Catalytic Reduction (SNCR)
N04906	Process Heaters - Other Fuel	NOX	Selective Catalytic Reduction (SCR)
N04907	Process Heaters - Other Fuel	NOX	Low NOx Burner (LNB) + Selective Catalytic Reduction (SCR)

Table II-2 (continued)

Measure Code	Source Category	Major Pollutant	Control Measure
N0491S	Process Heaters - Other Fuel	NOX	Low NOx Burner + Flue Gas Recirculation
N0492S	Process Heaters - Other Fuel	NOX	Low NOx Burner
N0493S	Process Heaters - Other Fuel	NOX	Selective Non-Catalytic Reduction (SNCR)
N0494S	Process Heaters - Other Fuel	NOX	Ultra Low NOx Burner
N0495S	Process Heaters - Other Fuel	NOX	Low NOx Burner - Selective Non-Catalytic Reduction (SNCR)
N0496S	Process Heaters - Other Fuel	NOX	Selective Catalytic Reduction (SCR)
N0497S	Process Heaters - Other Fuel	NOX	Low NOx Burner (LNB) + Selective Catalytic Reduction (SCR)
N05001	Combustion Turbines - Jet Fuel	NOX	Water Injection
N05002	Combustion Turbines - Jet Fuel	NOX	Selective Catalytic Reduction (SCR) + Water Injection
N0501S	Combustion Turbines - Jet Fuel	NOX	Water Injection
N0502S	Combustion Turbines - Jet Fuel	NOX	Selective Catalytic Reduction (SCR) + Water Injection
N05401	Space Heaters - Distillate Oil	NOX	Low NOx Burner
N05402	Space Heaters - Distillate Oil	NOX	Low NOx Burner + Flue Gas Recirculation
N05403	Space Heaters - Distillate Oil	NOX	Selective Catalytic Reduction (SCR)
N05404	Space Heaters - Distillate Oil	NOX	Selective Non-Catalytic Reduction (SNCR)
N0541S	Space Heaters - Distillate Oil	NOX	Low NOx Burner
N0542S	Space Heaters - Distillate Oil	NOX	Low NOx Burner + Flue Gas Recirculation
N0543S	Space Heaters - Distillate Oil	NOX	Selective Catalytic Reduction (SCR)
N0544S	Space Heaters - Distillate Oil	NOX	Selective Non-Catalytic Reduction (SNCR)
N05501	Space Heaters - Natural Gas	NOX	Low NOx Burner
N05502	Space Heaters - Natural Gas	NOX	Low NOx Burner + Flue Gas Recirculation
N05503	Space Heaters - Natural Gas	NOX	Oxygen Trim + Water Injection
N05504	Space Heaters - Natural Gas	NOX	Selective Catalytic Reduction (SCR)
N05505	Space Heaters - Natural Gas	NOX	Selective Non-Catalytic Reduction (SNCR)
N0551S	Space Heaters - Natural Gas	NOX	Low NOx Burner
N0552S	Space Heaters - Natural Gas	NOX	Low NOx Burner + Flue Gas Recirculation
N0553S	Space Heaters - Natural Gas	NOX	Oxygen Trim + Water Injection
N0554S	Space Heaters - Natural Gas	NOX	Selective Catalytic Reduction (SCR)
N0555S	Space Heaters - Natural Gas	NOX	Selective Non-Catalytic Reduction (SNCR)
N05601	Ammonia - NG-Fired Reformers	NOX	Low NOx Burner
N05602	Ammonia - NG-Fired Reformers	NOX	Low NOx Burner + Flue Gas Recirculation
N05603	Ammonia - NG-Fired Reformers	NOX	Oxygen Trim + Water Injection
N05604	Ammonia - NG-Fired Reformers	NOX	Selective Catalytic Reduction (SCR)
N05605	Ammonia - NG-Fired Reformers	NOX	Selective Non-Catalytic Reduction (SNCR)
N0561S	Ammonia - NG-Fired Reformers	NOX	Low NOx Burner
N0562S	Ammonia - NG-Fired Reformers	NOX	Low NOx Burner (LNB) + Flue Gas Recirculation (FGR)
N0563S	Ammonia - NG-Fired Reformers	NOX	Oxygen Trim + Water Injection
N0564S	Ammonia - NG-Fired Reformers	NOX	Selective Catalytic Reduction (SCR)
N0565S	Ammonia - NG-Fired Reformers	NOX	Selective Non-Catalytic Reduction (SNCR)
N05801	Lime Kilns	NOX	Mid-Kiln Firing
N05802	Lime Kilns	NOX	Low NOx Burner
N05803	Lime Kilns	NOX	Selective Non-Catalytic Reduction (SNCR) Urea Based
N05804	Lime Kilns	NOX	Selective Non-Catalytic Reduction (SNCR) Ammonia Based
N05805	Lime Kilns	NOX	Selective Catalytic Reduction (SCR)
N0581L	Lime Kilns	NOX	Mid-Kiln Firing
N0581S	Lime Kilns	NOX	Mid-Kiln Firing
N0582S	Lime Kilns	NOX	Low NOx Burner
N0583S	Lime Kilns	NOX	Selective Non-Catalytic Reduction (SNCR) Urea Based

Table II-2 (continued)

Measure Code	Source Category	Major Pollutant	Control Measure
N0584S	Lime Kilns	NOX	Selective Non-Catalytic Reduction (SNCR) Ammonia Based
N0585S	Lime Kilns	NOX	Selective Catalytic Reduction (SCR)
N05901	Comm./Inst. Incinerators	NOX	Selective Non-Catalytic Reduction (SNCR)
N0591S	Comm./Inst. Incinerators	NOX	Selective Non-Catalytic Reduction (SNCR)
N06001	Indust. Incinerators	NOX	Selective Non-Catalytic Reduction (SNCR)
N0601S	Indust. Incinerators	NOX	Selective Non-Catalytic Reduction (SNCR)
N06101	Sulfate Pulping - Recovery Furnaces	NOX	Low NOx Burner
N06102	Sulfate Pulping - Recovery Furnaces	NOX	Low NOx Burner + Flue Gas Recirculation
N06103	Sulfate Pulping - Recovery Furnaces	NOX	Oxygen Trim + Water Injection
N06104	Sulfate Pulping - Recovery Furnaces	NOX	Selective Catalytic Reduction (SCR)
N06105	Sulfate Pulping - Recovery Furnaces	NOX	Selective Non-Catalytic Reduction (SNCR)
N0611S	Sulfate Pulping - Recovery Furnaces	NOX	Low NOx Burner
N0612S	Sulfate Pulping - Recovery Furnaces	NOX	Low NOx Burner + Flue Gas Recirculation
N0613S	Sulfate Pulping - Recovery Furnaces	NOX	Oxygen Trim + Water Injection
N0614S	Sulfate Pulping - Recovery Furnaces	NOX	Selective Catalytic Reduction (SCR)
N0615S	Sulfate Pulping - Recovery Furnaces	NOX	Selective Non-Catalytic Reduction (SNCR)
N06202	Ammonia Prod; Feedstock Desulfurization	NOX	Low NOx Burner + Flue Gas Recirculation
N0622S	Ammonia Prod; Feedstock Desulfurization	NOX	Low NOx Burner + Flue Gas Recirculation
N06302	Plastics Prod-Specific; (ABS)	NOX	Low NOx Burner + Flue Gas Recirculation
N0632S	Plastics Prod-Specific; (ABS)	NOX	Low NOx Burner + Flue Gas Recirculation
N06402	Starch Mfg; Combined Operation	NOX	Low NOx Burner + Flue Gas Recirculation
N0642S	Starch Mfg; Combined Operation	NOX	Low NOx Burner + Flue Gas Recirculation
N06503	By-Product Coke Mfg; Oven Underfiring	NOX	Selective Non-Catalytic Reduction (SNCR)
N0653S	By-Product Coke Mfg; Oven Underfiring	NOX	Selective Non-Catalytic Reduction (SNCR)
N06703	Iron Prod; Blast Furn; Blast Htg Stoves	NOX	Low NOx Burner + Flue Gas Recirculation
N0673S	Iron Prod; Blast Furn; Blast Htg Stoves	NOX	Low NOx Burner + Flue Gas Recirculation
N06802	Steel Prod; Soaking Pits	NOX	Low NOx Burner + Flue Gas Recirculation
N0682S	Steel Prod; Soaking Pits	NOX	Low NOx Burner + Flue Gas Recirculation
N06902	Fuel Fired Equip; Process Htrs; Process Gas	NOX	Low NOx Burner + Flue Gas Recirculation
N0692S	Fuel Fired Equip; Process Htrs; Process Gas	NOX	Low NOx Burner + Flue Gas Recirculation
N07001	Sec Alum Prod; Smelting Furn	NOX	Low NOx Burner
N0701S	Sec Alum Prod; Smelting Furn	NOX	Low NOx Burner
N07101	Steel Foundries; Heat Treating	NOX	Low NOx Burner
N0711S	Steel Foundries; Heat Treating	NOX	Low NOx Burner
N07201	Fuel Fired Equip; Furnaces; Natural Gas	NOX	Low NOx Burner
N0721L	Fuel Fired Equip; Furnaces; Natural Gas	NOX	Low NOx Burner
N0721S	Fuel Fired Equip; Furnaces; Natural Gas	NOX	Low NOx Burner
N07301	Asphaltic Conc; Rotary Dryer; Conv Plant	NOX	Low NOx Burner
N0731S	Asphaltic Conc; Rotary Dryer; Conv Plant	NOX	Low NOx Burner
N07401	Ceramic Clay Mfg; Drying	NOX	Low NOx Burner
N0741S	Ceramic Clay Mfg; Drying	NOX	Low NOx Burner
N07503	Coal Cleaning-Thrml Dryer; Fluidized Bed	NOX	Low NOx Burner
N0753S	Coal Cleaning-Thrml Dryer; Fluidized Bed	NOX	Low NOx Burner
N07603	Fiberglass Mfg; Textile -Type Fbr; Recup Furn	NOX	Low NOx Burner
N0763S	Fiberglass Mfg; Textile -Type Fbr; Recup Furn	NOX	Low NOx Burner
N07702	Sand/Gravel; Dryer	NOX	Low NOx Burner + Flue Gas Recirculation
N0772S	Sand/Gravel; Dryer	NOX	Low NOx Burner + Flue Gas Recirculation
N07802	Fluid Cat Cracking Units	NOX	Low NOx Burner + Flue Gas Recirculation

Table II-2 (continued)

Measure Code	Source Category	Major Pollutant	Control Measure
N0782S	Fluid Cat Cracking Units	NOX	Low NOx Burner + Flue Gas Recirculation
N07901	Conv Coating of Prod; Acid Cleaning Bath	NOX	Low NOx Burner
N0791S	Conv Coating of Prod; Acid Cleaning Bath	NOX	Low NOx Burner
N08012	Natural Gas Prod; Compressors	NOX	Selective Catalytic Reduction (SCR)
N08103	In-Process; Bituminous Coal; Cement Kilns	NOX	Selective Non-Catalytic Reduction (SNCR) Urea Based
N0813S	In-Process; Bituminous Coal; Cement Kilns	NOX	Selective Non-Catalytic Reduction (SNCR) Urea Based
N08203	In-Process; Bituminous Coal; Lime Kilns	NOX	Selective Non-Catalytic Reduction (SNCR) Urea Based
N0823S	In-Process; Bituminous Coal; Lime Kilns	NOX	Selective Non-Catalytic Reduction (SNCR) Urea Based
N08301	In-Process Fuel Use; Bituminous Coal	NOX	Selective Non-Catalytic Reduction (SNCR)
N0831S	In-Process Fuel Use; Bituminous Coal	NOX	Selective Non-Catalytic Reduction (SNCR)
N08402	In-Process Fuel Use; Residual Oil	NOX	Low NOx Burner
N0842S	In-Process Fuel Use; Residual Oil	NOX	Low NOx Burner
N08501	In-Process Fuel Use; Natural Gas	NOX	Low NOx Burner
N0851S	In-Process Fuel Use; Natural Gas	NOX	Low NOx Burner
N08602	In-Process; Process Gas; Coke Oven Gas	NOX	Low NOx Burner + Flue Gas Recirculation
N0862S	In-Process; Process Gas; Coke Oven Gas	NOX	Low NOx Burner + Flue Gas Recirculation
N08701	In-Process; Process Gas; Coke Oven Gas	NOX	Low NOx Burner
N0871S	In-Process; Process Gas; Coke Oven Gas	NOX	Low NOx Burner
N08801	Surf Coat Oper; Coating Oven Htr; Nat Gas	NOX	Low NOx Burner
N0881S	Surf Coat Oper; Coating Oven Htr; Nat Gas	NOX	Low NOx Burner
N08901	Solid Waste Disp; Gov; Other Inc	NOX	Selective Non-Catalytic Reduction (SNCR)
N0891S	Solid Waste Disp; Gov; Other Inc	NOX	Selective Non-Catalytic Reduction (SNCR)
N10001	Industrial Coal Combustion	NOX	RACT to 50 tpy (LNB)
N10002	Industrial Coal Combustion	NOX	RACT to 25 tpy (LNB)
N10101	Industrial Oil Combustion	NOX	RACT to 50 tpy (LNB)
N10102	Industrial Oil Combustion	NOX	RACT to 25 tpy (LNB)
N10201	Industrial NG Combustion	NOX	RACT to 50 tpy (LNB)
N10202	Industrial NG Combustion	NOX	RACT to 25 tpy (LNB)
N10601	Commercial/Institutional - NG	NOX	Water Heater Replacement
N10603	Commercial/Institutional - NG	NOX	Water Heaters + LNB Space Heaters
N10901	Residential NG	NOX	Water Heater Replacement
N10903	Residential NG	NOX	Water Heater + LNB Space Heaters
N12201	Open Burning	NOX	Episodic Ban (Daily Only)
N13201	Agricultural Burning	NOX	Seasonal Ban (Ozone Season Daily)
N13701	Diesel Locomotives	NOX	Selective Catalytic Reduction (SCR)
NCEMK	Cement Kilns	NOX	Biosolid Injection Technology
P2011	Industrial Boilers - Coal	PM	Fabric Filter (Pulse Jet Type)
P2012	Industrial Boilers - Coal	PM	Dry ESP-Wire Plate Type
P2013	Industrial Boilers - Coal	PM	Fabric Filter (Reverse-Air Cleaned Type)
P2014	Industrial Boilers - Coal	PM	Venturi Scrubber
P2021	Industrial Boilers - Wood	PM	Fabric Filter (Pulse Jet Type)
P2022	Industrial Boilers - Wood	PM	Dry ESP-Wire Plate Type
P2023	Industrial Boilers - Wood	PM	Fabric Filter (Reverse-Air Cleaned Type)
P2024	Industrial Boilers - Wood	PM	Venturi Scrubber
P2031	Industrial Boilers - Oil	PM	Dry ESP-Wire Plate Type

Table II-2 (continued)

Measure Code	Source Category	Major Pollutant	Control Measure
P2032	Industrial Boilers - Oil	PM	Venturi Scrubber
P2041	Industrial Boilers - Liquid Waste	PM	Dry ESP-Wire Plate Type
P2051	Commercial Institutional Boilers	PM	Fabric Filter (Pulse Jet Type)
P2052	Commercial Institutional Boilers	PM	Dry ESP-Wire Plate Type
P2053	Commercial Institutional Boilers	PM	Fabric Filter (Reverse-Air Cleaned Type)
P2061	Commercial Institutional Boilers	PM	Fabric Filter (Pulse Jet Type)
P2062	Commercial Institutional Boilers	PM	Dry ESP-Wire Plate Type
P2063	Commercial Institutional Boilers	PM	Fabric Filter (Reverse-Air Cleaned Type)
P2071	Commercial Institutional Boilers	PM	Dry ESP-Wire Plate Type
P2081	Non-Ferrous Metals Processing	PM	Fabric Filter (Mech. Shaker Type)
P2082	Non-Ferrous Metals Processing	PM	Dry ESP-Wire Plate Type
P2083	Non-Ferrous Metals Processing	PM	Wet ESP - Wire Plate Type
P2084	Non-Ferrous Metals Processing	PM	Fabric Filter (Reverse-Air Cleaned Type)
P2091	Non-Ferrous Metals Processing	PM	Fabric Filter (Mech. Shaker Type)
P2092	Non-Ferrous Metals Processing	PM	Dry ESP-Wire Plate Type
P2093	Non-Ferrous Metals Processing	PM	Wet ESP - Wire Plate Type
P2094	Non-Ferrous Metals Processing	PM	Fabric Filter (Reverse-Air Cleaned Type)
P2101	Non-Ferrous Metals Processing	PM	Fabric Filter (Mech. Shaker Type)
P2102	Non-Ferrous Metals Processing	PM	Dry ESP-Wire Plate Type
P2103	Non-Ferrous Metals Processing	PM	Wet ESP - Wire Plate Type
P2104	Non-Ferrous Metals Processing	PM	Fabric Filter (Reverse-Air Cleaned Type)
P2111	Non-Ferrous Metals Processing	PM	Fabric Filter (Mech. Shaker Type)
P2112	Non-Ferrous Metals Processing	PM	Dry ESP-Wire Plate Type
P2113	Non-Ferrous Metals Processing	PM	Wet ESP - Wire Plate Type
P2114	Non-Ferrous Metals Processing	PM	Fabric Filter (Reverse-Air Cleaned Type)
P2121	Non-Ferrous Metals Processing	PM	Fabric Filter (Mech. Shaker Type)
P2122	Non-Ferrous Metals Processing	PM	Dry ESP-Wire Plate Type
P2123	Non-Ferrous Metals Processing	PM	Wet ESP - Wire Plate Type
P2124	Non-Ferrous Metals Processing	PM	Fabric Filter (Reverse-Air Cleaned Type)
P2131	Ferrous Metals Processing - Coke	PM	Fabric Filter (Mech. Shaker Type)
P2132	Ferrous Metals Processing - Coke	PM	Fabric Filter (Reverse-Air Cleaned Type)
P2133	Ferrous Metals Processing - Coke	PM	Venturi Scrubber
P2141	Ferrous Metals Processing - Ferroalloy Production	PM	Fabric Filter (Mech. Shaker Type)
P2142	Ferrous Metals Processing - Ferroalloy Production	PM	Dry ESP-Wire Plate Type
P2143	Ferrous Metals Processing - Ferroalloy Production	PM	Fabric Filter (Reverse-Air Cleaned Type)
P2151	Ferrous Metals Processing - Iron and Steel Production	PM	Fabric Filter (Pulse Jet Type)
P2152	Ferrous Metals Processing - Iron and Steel Production	PM	Fabric Filter (Mech. Shaker Type)
P2153	Ferrous Metals Processing - Iron and Steel Production	PM	Dry ESP-Wire Plate Type
P2154	Ferrous Metals Processing - Iron and Steel Production	PM	Wet ESP - Wire Plate Type
P2155	Ferrous Metals Processing - Iron and Steel Production	PM	Fabric Filter (Reverse-Air Cleaned Type)
P2156	Ferrous Metals Processing - Iron and Steel Production	PM	Venturi Scrubber
P2161	Ferrous Metals Processing - Gray Iron Foundries	PM	Fabric Filter (Mech. Shaker Type)
P2162	Ferrous Metals Processing - Gray Iron Foundries	PM	Dry ESP-Wire Plate Type
P2163	Ferrous Metals Processing - Gray Iron Foundries	PM	Fabric Filter (Reverse-Air Cleaned Type)

Table II-2 (continued)

Measure Code	Source Category	Major Pollutant	Control Measure
P2164	Ferrous Metals Processing - Gray Iron Foundries	PM	Impingement-Plate Scrubber
P2165	Ferrous Metals Processing - Gray Iron Foundries	PM	Venturi Scrubber
P2171	Ferrous Metals Processing - Steel Foundries	PM	Fabric Filter (Pulse Jet Type)
P2172	Ferrous Metals Processing - Steel Foundries	PM	Fabric Filter (Mech. Shaker Type)
P2173	Ferrous Metals Processing - Steel Foundries	PM	Dry ESP-Wire Plate Type
P2174	Ferrous Metals Processing - Steel Foundries	PM	Wet ESP - Wire Plate Type
P2175	Ferrous Metals Processing - Steel Foundries	PM	Fabric Filter (Reverse-Air Cleaned Type)
P2176	Ferrous Metals Processing - Steel Foundries	PM	Venturi Scrubber
P2181	Mineral Products - Cement Manufacture	PM	Fabric Filter (Pulse Jet Type)
P2182	Mineral Products - Cement Manufacture	PM	Fabric Filter (Mech. Shaker Type)
P2183	Mineral Products - Cement Manufacture	PM	Dry ESP-Wire Plate Type
P2184	Mineral Products - Cement Manufacture	PM	Paper/Nonwoven Filters - Cartridge Collector Type
P2185	Mineral Products - Cement Manufacture	PM	Fabric Filter (Reverse-Air Cleaned Type)
P2191	Mineral Products - Coal Cleaning	PM	Fabric Filter (Pulse Jet Type)
P2192	Mineral Products - Coal Cleaning	PM	Fabric Filter (Mech. Shaker Type)
P2193	Mineral Products - Coal Cleaning	PM	Paper/Nonwoven Filters - Cartridge Collector Type
P2194	Mineral Products - Coal Cleaning	PM	Fabric Filter (Reverse-Air Cleaned Type)
P2195	Mineral Products - Coal Cleaning	PM	Venturi Scrubber
P2201	Mineral Products - Stone Quarrying and Processing	PM	Fabric Filter (Pulse Jet Type)
P2202	Mineral Products - Stone Quarrying and Processing	PM	Fabric Filter (Mech. Shaker Type)
P2203	Mineral Products - Stone Quarrying and Processing	PM	Dry ESP-Wire Plate Type
P2204	Mineral Products - Stone Quarrying and Processing	PM	Wet ESP - Wire Plate Type
P2205	Mineral Products - Stone Quarrying and Processing	PM	Paper/Nonwoven Filters - Cartridge Collector Type
P2206	Mineral Products - Stone Quarrying and Processing	PM	Fabric Filter (Reverse-Air Cleaned Type)
P2207	Mineral Products - Stone Quarrying and Processing	PM	Venturi Scrubber
P2211	Mineral Products - Other	PM	Fabric Filter (Pulse Jet Type)
P2212	Mineral Products - Other	PM	Fabric Filter (Mech. Shaker Type)
P2213	Mineral Products - Other	PM	Dry ESP-Wire Plate Type
P2214	Mineral Products - Other	PM	Wet ESP - Wire Plate Type
P2215	Mineral Products - Other	PM	Paper/Nonwoven Filters - Cartridge Collector Type
P2216	Mineral Products - Other	PM	Fabric Filter (Reverse-Air Cleaned Type)
P2221	Asphalt Manufacture	PM	Fabric Filter (Pulse Jet Type)
P2222	Asphalt Manufacture	PM	Fabric Filter (Mech. Shaker Type)
P2223	Asphalt Manufacture	PM	Paper/Nonwoven Filters - Cartridge Collector Type
P2224	Asphalt Manufacture	PM	Fabric Filter (Reverse-Air Cleaned Type)
P2231	Grain Milling	PM	Fabric Filter (Pulse Jet Type)
P2232	Grain Milling	PM	Paper/Nonwoven Filters - Cartridge Collector Type
P2233	Grain Milling	PM	Fabric Filter (Reverse-Air Cleaned Type)

Table II-2 (continued)

Measure Code	Source Category	Major Pollutant	Control Measure
P2241	Wood Pulp & Paper	PM	Dry ESP-Wire Plate Type
P2242	Wood Pulp & Paper	PM	Wet ESP - Wire Plate Type
P2251	Chemical Manufacture	PM	Wet ESP - Wire Plate Type
P2261	Municipal Waste Incineration	PM	Dry ESP-Wire Plate Type
P2271	Fabricated Metal Products - Abrasive Blasting	PM	Paper/Nonwoven Filters - Cartridge Collector Type
P2291	Fabricated Metal Products - Welding	PM	Paper/Nonwoven Filters - Cartridge Collector Type
P3201	Industrial Boilers - Coal	PM	Increased Monitoring Frequency (IMF) of PM Control
P3202	Industrial Boilers - Wood	PM	Increased Monitoring Frequency (IMF) of PM Control
P3203	Industrial Boilers - Oil	PM	Increased Monitoring Frequency (IMF) of PM Control
P3204	Industrial Boilers - Liquid Waste	PM	Increased Monitoring Frequency (IMF) of PM Control
P3205	Commercial Institutional Boilers - Coal	PM	Increased Monitoring Frequency (IMF) of PM Control
P3206	Commercial Institutional Boilers - Wood	PM	Increased Monitoring Frequency (IMF) of PM Control
P3207	Commercial Institutional Boilers - Oil	PM	Increased Monitoring Frequency (IMF) of PM Control
P3208	Non-Ferrous Metals Processing - Copper	PM	Increased Monitoring Frequency (IMF) of PM Control
P3209	Non-Ferrous Metals Processing - Lead	PM	Increased Monitoring Frequency (IMF) of PM Control
P3210	Non-Ferrous Metals Processing - Zinc	PM	Increased Monitoring Frequency (IMF) of PM Control
P3211	Non-Ferrous Metals Processing - Aluminum	PM	Increased Monitoring Frequency (IMF) of PM Control
P3212	Non-Ferrous Metals Processing - Other	PM	Increased Monitoring Frequency (IMF) of PM Control
P3213	Ferrous Metals Processing - Coke	PM	Increased Monitoring Frequency (IMF) of PM Control
P3214	Ferrous Metals Processing - Ferroalloy Production	PM	Increased Monitoring Frequency (IMF) of PM Control
P3215	Ferrous Metals Processing - Iron & Steel Production	PM	Increased Monitoring Frequency (IMF) of PM Control
P3216	Ferrous Metals Processing - Gray Iron Foundries	PM	Increased Monitoring Frequency (IMF) of PM Control
P3217	Ferrous Metals Processing - Steel Foundries	PM	Increased Monitoring Frequency (IMF) of PM Control
P3218	Mineral Products - Cement Manufacture	PM	Increased Monitoring Frequency (IMF) of PM Control
P3219	Mineral Products - Coal Cleaning	PM	Increased Monitoring Frequency (IMF) of PM Control
P3220	Mineral Products - Stone Quarrying & Processing	PM	Increased Monitoring Frequency (IMF) of PM Control
P3221	Mineral Products - Other	PM	Increased Monitoring Frequency (IMF) of PM Control
P3222	Asphalt Manufacture	PM	Increased Monitoring Frequency (IMF) of PM Control
P3225	Chemical Manufacture	PM	Increased Monitoring Frequency (IMF) of PM Control
P3226	Electric Generation - Coal	PM	Increased Monitoring Frequency (IMF) of PM Control
P3227	Commercial Institutional Boilers - LPG	PM	Increased Monitoring Frequency (IMF) of PM Control

Table II-2 (continued)

Measure Code	Source Category	Major Pollutant	Control Measure
P3228	Commercial Institutional Boilers - Liquid Waste	PM	Increased Monitoring Frequency (IMF) of PM Control
P3229	Commercial Institutional Boilers - Natural Gas	PM	Increased Monitoring Frequency (IMF) of PM Control
P3230	Commercial Institutional Boilers - Process Gas	PM	Increased Monitoring Frequency (IMF) of PM Control
P3231	Commercial Institutional Boilers - Solid Waste	PM	Increased Monitoring Frequency (IMF) of PM Control
P3232	Electric Generation - Coke	PM	Increased Monitoring Frequency (IMF) of PM Control
P3233	Electric Generation - Bagasse	PM	Increased Monitoring Frequency (IMF) of PM Control
P3234	Electric Generation - LPG	PM	Increased Monitoring Frequency (IMF) of PM Control
P3235	Electric Generation - Liquid Waste	PM	Increased Monitoring Frequency (IMF) of PM Control
P3236	Electric Generation - Natural Gas	PM	Increased Monitoring Frequency (IMF) of PM Control
P3237	Electric Generation - Oil	PM	Increased Monitoring Frequency (IMF) of PM Control
P3238	Electric Generation - Solid Waste	PM	Increased Monitoring Frequency (IMF) of PM Control
P3239	Electric Generation - Wood	PM	Increased Monitoring Frequency (IMF) of PM Control
P3240	Ferrous Metals Processing - Other	PM	Increased Monitoring Frequency (IMF) of PM Control
P3241	Industrial Boilers - Coke	PM	Increased Monitoring Frequency (IMF) of PM Control
P3242	Industrial Boilers - LPG	PM	Increased Monitoring Frequency (IMF) of PM Control
P3243	Industrial Boilers - Natural Gas	PM	Increased Monitoring Frequency (IMF) of PM Control
P3244	Industrial Boilers - Process Gas	PM	Increased Monitoring Frequency (IMF) of PM Control
P3245	Industrial Boilers - Solid Waste	PM	Increased Monitoring Frequency (IMF) of PM Control
P4201	Industrial Boilers - Coal	PM	Increased Monitoring Frequency (IMF) of PM Control
P4202	Industrial Boilers - Wood	PM	CEM Upgrade and Increased Monitoring Frequency of PM Controls
P4203	Industrial Boilers - Oil	PM	CEM Upgrade and Increased Monitoring Frequency of PM Controls
P4204	Industrial Boilers - Liquid Waste	PM	CEM Upgrade and Increased Monitoring Frequency of PM Controls
P4205	Commercial Institutional Boilers - Coal	PM	CEM Upgrade and Increased Monitoring Frequency of PM Controls
P4206	Commercial Institutional Boilers - Wood	PM	CEM Upgrade and Increased Monitoring Frequency of PM Controls
P4207	Commercial Institutional Boilers - Oil	PM	CEM Upgrade and Increased Monitoring Frequency of PM Controls
P4208	Non-Ferrous Metals Processing - Copper	PM	CEM Upgrade and Increased Monitoring Frequency of PM Controls
P4209	Non-Ferrous Metals Processing - Lead	PM	CEM Upgrade and Increased Monitoring Frequency of PM Controls
P4210	Non-Ferrous Metals Processing - Zinc	PM	CEM Upgrade and Increased Monitoring Frequency of PM Controls
P4211	Non-Ferrous Metals Processing - Aluminum	PM	CEM Upgrade and Increased Monitoring Frequency of PM Controls

Table II-2 (continued)

Measure Code	Source Category	Major Pollutant	Control Measure
P4212	Non-Ferrous Metals Processing - Other	PM	CEM Upgrade and Increased Monitoring Frequency of PM Controls
P4213	Ferrous Metals Processing - Coke	PM	CEM Upgrade and Increased Monitoring Frequency of PM Controls
P4214	Ferrous Metals Processing - Ferroalloy Production	PM	CEM Upgrade and Increased Monitoring Frequency of PM Controls
P4215	Ferrous Metals Processing - Iron & Steel Production	PM	CEM Upgrade and Increased Monitoring Frequency of PM Controls
P4216	Ferrous Metals Processing - Gray Iron Foundries	PM	CEM Upgrade and Increased Monitoring Frequency of PM Controls
P4217	Ferrous Metals Processing - Steel Foundries	PM	CEM Upgrade and Increased Monitoring Frequency of PM Controls
P4218	Mineral Products - Cement Manufacture	PM	CEM Upgrade and Increased Monitoring Frequency of PM Controls
P4219	Mineral Products - Coal Cleaning	PM	CEM Upgrade and Increased Monitoring Frequency of PM Controls
P4220	Mineral Products - Stone Quarrying & Processing	PM	CEM Upgrade and Increased Monitoring Frequency of PM Controls
P4221	Mineral Products - Other	PM	CEM Upgrade and Increased Monitoring Frequency of PM Controls
P4222	Asphalt Manufacture	PM	CEM Upgrade and Increased Monitoring Frequency of PM Controls
P4225	Chemical Manufacture	PM	CEM Upgrade and Increased Monitoring Frequency of PM Controls
P4226	Electric Generation - Coal	PM	CEM Upgrade and Increased Monitoring Frequency of PM Controls
P4227	Commercial Institutional Boilers - LPG	PM	CEM Upgrade and Increased Monitoring Frequency of PM Controls
P4228	Commercial Institutional Boilers - Liquid Waste	PM	CEM Upgrade and Increased Monitoring Frequency of PM Controls
P4229	Commercial Institutional Boilers - Natural Gas	PM	CEM Upgrade and Increased Monitoring Frequency of PM Controls
P4230	Commercial Institutional Boilers - Process Gas	PM	CEM Upgrade and Increased Monitoring Frequency of PM Controls
P4231	Commercial Institutional Boilers - Solid Waste	PM	CEM Upgrade and Increased Monitoring Frequency of PM Controls
P4232	Electric Generation - Coke	PM	CEM Upgrade and Increased Monitoring Frequency of PM Controls
P4233	Electric Generation - Bagasse	PM	CEM Upgrade and Increased Monitoring Frequency of PM Controls
P4234	Electric Generation - LPG	PM	CEM Upgrade and Increased Monitoring Frequency of PM Controls
P4235	Electric Generation - Liquid Waste	PM	CEM Upgrade and Increased Monitoring Frequency of PM Controls
P4236	Electric Generation - Natural Gas	PM	CEM Upgrade and Increased Monitoring Frequency of PM Controls
P4237	Electric Generation - Oil	PM	CEM Upgrade and Increased Monitoring Frequency of PM Controls
P4238	Electric Generation - Solid Waste	PM	CEM Upgrade and Increased Monitoring Frequency of PM Controls
P4239	Electric Generation - Wood	PM	CEM Upgrade and Increased Monitoring Frequency of PM Controls
P4240	Ferrous Metals Processing - Other	PM	CEM Upgrade and Increased Monitoring Frequency of PM Controls
P4241	Industrial Boilers - Coke	PM	CEM Upgrade and Increased Monitoring Frequency of PM Controls
P4242	Industrial Boilers - LPG	PM	CEM Upgrade and Increased Monitoring Frequency of PM Controls

Table II-2 (continued)

Measure Code	Source Category	Major Pollutant	Control Measure
P4243	Industrial Boilers - Natural Gas	PM	CEM Upgrade and Increased Monitoring Frequency of PM Controls
P4244	Industrial Boilers - Process Gas	PM	CEM Upgrade and Increased Monitoring Frequency of PM Controls
P4245	Industrial Boilers - Solid Waste	PM	CEM Upgrade and Increased Monitoring Frequency of PM Controls
PHDRET	Nonroad Diesel Engines	PM	Heavy Duty Retrofit Program
PPVAC	Paved Road	PM	Vacuum Sweeping
PUCHS	Unpaved Road	PM	Chemical Stabilization
PUDESP	Utility Boilers - Coal	PM	Dry ESP-Wire Plate Type
PUHAP	Unpaved Rd	PM	Hot Asphalt Paving
PUMECH	Utility Boilers - Coal	PM	Fabric Filter (Mech. Shaker Type)
PUPUJT	Utility Boilers - Coal	PM	Fabric Filter (Pulse Jet Type)
PUREVA	Utility Boilers - Coal	PM	Fabric Filter (Reverse-Air Cleaned Type)
PUTILC	Utility Boilers - Coal	PM	Fabric Filter
PUTILG	Utility Boilers - Gas/Oil	PM	Fabric Filter
Pagbu	Agricultural Burning	PM	Bale Stack/Propane Burning
Pagtl	Agricultural Tilling	PM	Soil Conservation Plans
Pcatf	Beef Cattle Feedlots	PM	Watering
Pcharb	Conveyorized Charbroilers	PM	Catalytic Oxidizer
Pcnst	Construction Activities	PM	Dust Control Plan
Ppreb	Prescribed Burning	PM	Increase Fuel Moisture
Presw	Residential Wood Combustion	PM	Education and Advisory Program
Pwdstv	Residential Wood Stoves	PM	NSPS compliant Wood Stoves
S0201	Sulfuric Acid Plants - Contact Absorber (99% Conversion)	SO2	Increase % Conversion to Meet NSPS (99.7)
S0301	Sulfuric Acid Plants - Contact Absorber (98% Conversion)	SO2	Increase % Conversion to Meet NSPS (99.7)
S0401	Sulfuric Acid Plants - Contact Absorber (97% Conversion)	SO2	Increase % Conversion to Meet NSPS (99.7)
S0501	Sulfuric Acid Plants - Contact Absorber (93% Conversion)	SO2	Increase % Conversion to Meet NSPS (99.7)
S0601	Sulfur Recovery Plants - Elemental Sulfur (Claus: 2 Stage w/o control (92-95% removal))	SO2	Amine Scrubbing
S0602	Sulfur Recovery Plants - Elemental Sulfur (Claus: 2 Stage w/o control (92-95% removal))	SO2	Sulfur Recovery and/or Tail Gas treatment
S0701	Sulfur Recovery Plants - Elemental Sulfur (Claus: 3 Stage w/o control (95-96% removal))	SO2	Amine Scrubbing
S0702	Sulfur Recovery Plants - Elemental Sulfur (Claus: 3 Stage w/o control (95-96% removal))	SO2	Sulfur Recovery and/or Tail Gas treatment
S0801	Sulfur Recovery Plants - Elemental Sulfur (Claus: 4 Stage w/o control (96-97% removal))	SO2	Amine Scrubbing
S0802	Sulfur Recovery Plants - Elemental Sulfur (Claus: 3 Stage w/o control (96-97% removal))	SO2	Sulfur Recovery and/or Tail Gas treatment
S0901	Sulfur Recovery Plants - Sulfur Removal Process (99.9% removal)	SO2	Sulfur Recovery and/or Tail Gas treatment
S1001	Sulfur Recovery Plants - Elemental Sulfur Production (Not Classified)	SO2	Sulfur Recovery and/or Tail Gas treatment
S1101	Inorganic Chemical Manufacture	SO2	Flue Gas Desulfurization (FGD)
S1201	By-Product Coke Manufacturing (Coke Oven Plants)	SO2	Vacuum Carbonate Plus Sulfur Recovery Plant

Table II-2 (continued)

Measure Code	Source Category	Major Pollutant	Control Measure
S1301	Process Heaters (Oil and Gas Production Industry)	SO ₂	Flue Gas Desulfurization (FGD)
S1401	Primary Metals Industry	SO ₂	Sulfuric Acid Plant
S1501	Secondary Metal Production	SO ₂	Flue Gas Desulfurization (FGD)
S1601	Mineral Products Industry	SO ₂	Flue Gas Desulfurization (FGD)
S1701	Pulp and Paper Industry (Sulfate Pulping)	SO ₂	Flue Gas Desulfurization (FGD)
S1801	Petroleum Industry	SO ₂	Flue Gas Desulfurization (FGD)
S1901	Bituminous/Subbituminous Coal (Industrial Boilers)	SO ₂	Flue Gas Desulfurization (FGD)
S2001	Residual Oil (Industrial Boilers)	SO ₂	Flue Gas Desulfurization (FGD)
S2101	Bituminous/Subbituminous Coal (Commercial/Institutional Boilers)	SO ₂	Flue Gas Desulfurization (FGD)
S2201	In-process Fuel Use - Bituminous/Subbituminous Coal	SO ₂	Flue Gas Desulfurization (FGD)
S2301	Lignite (Industrial Boilers)	SO ₂	Flue Gas Desulfurization (FGD)
S2401	Residual Oil (Commercial/Institutional Boilers)	SO ₂	Flue Gas Desulfurization (FGD)
S2601	Steam Generating Unit-Coal/Oil	SO ₂	Flue Gas Desulfurization (FGD)
S2801	Primary Zinc Smelters - Sintering	SO ₂	Dual absorption
S2901	Primary Zinc Smelters - Sintering	SO ₂	Dual absorption
S3000	Bituminous/Subbituminous Coal (Industrial Boilers)	SO ₂	In-duct Dry Sorbent Injection
S3001	Bituminous/Subbituminous Coal (Industrial Boilers)	SO ₂	Spray Dryer Absorber
S3002	Bituminous/Subbituminous Coal (Industrial Boilers)	SO ₂	Wet Flue Gas Desulfurization
S3003	Lignite (Industrial Boilers)	SO ₂	In-duct Dry Sorbent Injection
S3004	Lignite (Industrial Boilers)	SO ₂	Spray Dryer Absorber
S3005	Lignite (Industrial Boilers)	SO ₂	Wet Flue Gas Desulfurization
S3006	Residual Oil (Industrial Boilers)	SO ₂	Wet Flue Gas Desulfurization
S3007	Distillate Oil (Industrial Boiler)	SO ₂	Wet Flue Gas Desulfurization
SI2010	Off-Highway Gasoline Vehicles	NO _X	2010 Implementation of Large Spark-Ignition (S-I) Engine Standards
SI2015	Off-Highway Gasoline Vehicles	NO _X	2015 Implementation of Large Spark-Ignition (S-I) Engine Standards
SI2020	Off-Highway Gasoline Vehicles	NO _X	2020 Implementation of Large Spark-Ignition (S-I) Engine Standards
SI2030	Off-Highway Gasoline Vehicles	NO _X	2030 Implementation of Large Spark-Ignition (S-I) Engine Standards
SM2010	Off-Highway Vehicles: Snowmobiles	VOC	Recreational Gasoline Snowmobile Standards
SM2015	Off-Highway Vehicles: Snowmobiles	VOC	Recreational Gasoline Snowmobile Standards
SM2020	Off-Highway Vehicles: Snowmobiles	VOC	Recreational Gasoline Snowmobile Standards
SM2030	Off-Highway Vehicles: Snowmobiles	VOC	Recreational Gasoline Snowmobile Standards
SUT-H	Utility Boilers - High Sulfur Content	SO ₂	Flue Gas Desulfurization (Wet Scrubber Type)
SUT-M	Utility Boilers - Medium Sulfur Content	SO ₂	Flue Gas Desulfurization (Wet Scrubber Type)
SUT-R	Utility Boilers - Coal-Fired	SO ₂	Repowering to IGCC
SUT-S	Utility Boilers - Coal-Fired	SO ₂	Fuel Switching - High-Sulfur Coal to Low-Sulfur Coal
SUT-VH	Utility Boilers - Very High Sulfur Content	SO ₂	Flue Gas Desulfurization (Wet Scrubber Type)
SUT-W	Utility Boilers - Coal-Fired	SO ₂	Coal Washing
T210	Highway Vehicles - Light Duty and Gasoline-Fueled Vehicles	NO _X	2010 Implementation of Tier 2 Motor Vehicle Emissions and Gasoline Sulfur Controls
T215	Highway Vehicles - Light Duty and Gasoline-Fueled Vehicles	NO _X	2015 Implementation of Tier 2 Motor Vehicle Emissions and Gasoline Sulfur Controls
T220	Highway Vehicles - Light Duty and Gasoline-Fueled Vehicles	NO _X	2020 Implementation of Tier 2 Motor Vehicle Emissions and Gasoline Sulfur Controls

Table II-2 (continued)

Measure Code	Source Category	Major Pollutant	Control Measure
T230	Highway Vehicles - Light Duty and Gasoline-Fueled Vehicles	NOX	2030 Implementation of Tier 2 Motor Vehicle Emissions and Gasoline Sulfur Controls
V22001	Architectural Coatings	VOC	AIM Coating Federal Rule
V22002	Architectural Coatings	VOC	South Coast Phase I
V22003	Architectural Coatings	VOC	South Coast Phase II
V22004	Architectural Coatings	VOC	South Coast Phase III
V22101	Traffic Markings	VOC	AIM Coating Federal Rule
V22102	Traffic Markings	VOC	South Coast Phase I
V22103	Traffic Markings	VOC	South Coast Phase II
V22104	Traffic Markings	VOC	South Coast Phase III
V22201	Industrial Maintenance Coating	VOC	AIM Coating Federal Rule
V22202	Industrial Maintenance Coating	VOC	South Coast Phase I
V22203	Industrial Maintenance Coating	VOC	South Coast Phase II
V22204	Industrial Maintenance Coating	VOC	South Coast Phase III
V22301	Metal Coil & Can Coating	VOC	MACT Standard
V22302	Metal Coil & Can Coating	VOC	BAAQMD Rule 11 Amended
V22303	Metal Coil & Can Coating	VOC	Incineration
V22401	Wood Product Surface Coating	VOC	MACT Standard
V22402	Wood Product Surface Coating	VOC	SCAQMD Rule 1104
V22403	Wood Product Surface Coating	VOC	Incineration
V22501	Wood Furniture Surface Coating	VOC	MACT Standard
V22502	Wood Furniture Surface Coating	VOC	New CTG
V22503	Wood Furniture Surface Coating	VOC	Add-On Controls
V22601	Adhesives - Industrial	VOC	SCAQMD Rule 1168
V23201	Open Top Degreasing	VOC	Title III MACT Standard
V23202	Open Top Degreasing	VOC	SCAQMD 1122 (VOC content limit)
V23203	Open Top Degreasing	VOC	Airtight Degreasing System
V24001	Paper Surface Coating	VOC	Incineration
V24401	Rubber and Plastics Mfg	VOC	SCAQMD - Low VOC
V24501	Metal Furniture, Appliances, Parts	VOC	MACT Standard
V24502	Metal Furniture, Appliances, Parts	VOC	SCAQMD Limits
V24601	Automobile Refinishing	VOC	Federal Rule
V24602	Automobile Refinishing	VOC	CARB BARCT Limits
V24603	Automobile Refinishing	VOC	California FIP Rule (VOC content & TE)
V24604	Cold Cleaning	VOC	OTC Solvent Cleaning Operations Rule
V24605	Portable Gasoline Containers	VOC	OTC Portable Gas Container Rule
V24606	Architectural Coatings	VOC	OTC AIM Coating Rule
V24607	Consumer Solvents	VOC	OTC Consumer Products Rule
V24608	Marine Surface Coating	VOC	OTC Mobile Equipment Repair and Refinishing Rule
V24701	Machn, Electric, Railroad Ctng	VOC	MACT Standard
V24702	Machn, Electric, Railroad Ctng	VOC	SCAQMD Limits
V24703	Machn, Electric, Railroad Ctng	VOC	OTC Mobile Equipment Repair and Refinishing Rule
V24901	Consumer Solvents	VOC	Federal Consumer Solvents Rule
V24902	Consumer Solvents	VOC	CARB Mid-Term Limits
V24903	Consumer Solvents	VOC	CARB Long-Term Limits
V25001	Aircraft Surface Coating	VOC	MACT Standard
V25002	Aircraft Surface Coating	VOC	OTC Mobile Equipment Repair and Refinishing Rule
V25101	Marine Surface Coating	VOC	MACT Standard
V25102	Marine Surface Coating	VOC	Add-On Controls
V25301	Electrical/Electronic Coating	VOC	MACT Standard
V25302	Electrical/Electronic Coating	VOC	SCAQMD Rule
V25401	Motor Vehicle Coating	VOC	MACT Standard
V25402	Motor Vehicle Coating	VOC	Incineration

Table II-2 (continued)

Measure Code	Source Category	Major Pollutant	Control Measure
V25403	Automobile Refinishing	VOC	OTC Mobile Equipment Repair and Refinishing Rule
V26901	Commercial Adhesives	VOC	Federal Consumer Solvents Rule
V26902	Commercial Adhesives	VOC	CARB Mid-Term Limits
V26903	Commercial Adhesives	VOC	CARB Long-Term Limits
V26904	Consumer Adhesives	VOC	OTC Consumer Products Rule
V27102	Bakery Products	VOC	Incineration >100,000 lbs bread
V27201	Cutback Asphalt	VOC	Switch to Emulsified Asphalts
V27901	Oil and Natural Gas Production	VOC	Equipment and Maintenance
V28402	Municipal Solid Waste Landfill	VOC	Gas Collection (SCAQMD/BAAQMD)
V29502	Pesticide Application	VOC	Reformulation - FIP Rule
V30101	Stage II Service Stations	VOC	Low Pressure/Vacuum Relief Valve
V30201	Stage II Service Stations - Underground Tanks	VOC	Low Pressure/Vacuum Relief Valve
V30301	Graphic Arts	VOC	Use of Low or No VOC Materials
V40201	Flexographic Printing	VOC	Permanent Total Enclosure (PTE)
V40202	Fabric Printing, Coating and Dyeing	VOC	Permanent Total Enclosure (PTE)
V40203	Metal Can Surface Coating	VOC	Permanent Total Enclosure (PTE)
V40204	Metal Furniture Surface Coating	VOC	Permanent Total Enclosure (PTE)
V40205	Paper and Other Web Coating	VOC	Permanent Total Enclosure (PTE)
V40206	Product and Package Roto and Screen Prin	VOC	Permanent Total Enclosure (PTE)
V40207	Publication Rotogravure Printing	VOC	Permanent Total Enclosure (PTE)
VNRFG	Nonroad Gasoline Engines	VOC	Federal Reformulated Gasoline
mOT1	Highway Veh - LD Gas Trucks	VOC	Tier 2 Standards for 1996
mOT2	Highway Vehicles - Gasoline	VOC	Federal Reformulated Gasoline (RFG)
mOT3	Highway Vehicles - Gasoline	NOX	High Enhanced Inspection and Maintenance Program
mOT4	Highway Veh - LD Gasoline	VOC	Fleet ILEV
mOT5	Highway Veh - HD Diesels	PM	HDDV Retrofit Program
mOT6	Highway Vehicles - Gasoline	NOX	Transportation Control Package for 1996
mOT7	Highway Vehicles - Gasoline	NOX	RFG and High Enhanced I/M Program
mOT8	Highway Vehicles - Gasoline	VOC	Low Reid Vapor Pressure (RVP) Limit in Ozone Season
mOT9	Highway Vehicles - Gasoline	VOC	Basic Inspection and Maintenance Program

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CHAPTER III. CONTROL DOCUMENTATION

Each control measure in AirControlNET is documented in this section. Control measures are introduced with a standard table that provides an at-a-glance summary of the key control measure data elements. Each summary table is followed by detailed sections that provide additional information concerning the control measure. References also are provided to the documents that were used to develop the analysis on each of the control measures.

This section is organized by primary pollutant (e.g., Ammonia, Nitrogen Oxides, Particulate Matter, etc.) and source category. The following pages provide a pollutant introduction, a list of source categories contained within each pollutant section.

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NITROGEN OXIDES (NO_x)

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SULFUR DIOXIDE (SO₂)

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VOLATILE ORGANIC COMPOUNDS (VOC)

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AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Cattle Feedlots

Control Measure Name: Chemical Additives to Waste

Rule Name: Not Applicable

Pechan Measure Code: A00101

POD: 01

Application: This control is the adding of chemicals to cattle waste to reduce ammonia emissions from cattle feedlots.

The control applies to all cattle and calve operations classified under SCC 280503000.

Affected SCC:

2805020000 Cattle and Calves Composite, Total

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
								√*		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 50% from uncontrolled

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Pechan contacted the manufacturer of the chemical inhibitor, N-(n-butyl) thiophosphoric triamide (NBPT; trade name Conserve-Nr). According to the manufacturer, the control effectiveness at cattle feedlots is 50 percent and the cost per head-day is \$0.0062 (\$2.26/head-yr; Axe, 1999). The manufacturer also reports that field tests are ongoing at dairies and that the product should perform the same (50 percent control), but cost slightly more \$0.0094/head-day (\$3.43/head-yr; Axe, 1999). It was not clear why the costs would be higher at dairies.

To estimate costs, an average per head cost between dairy cattle and feedlot cattle would be \$2.85/head-yr (from the above estimates). The emission factor for cattle is about 23 kg/head-yr (0.025 ton/head-yr). A 50 percent control efficiency yields 0.0125 ton/head-yr reduced). Hence, the cost factor would be \$2.85/0.0125 ton or \$228/ton of NH3 reduced.

Cost Effectiveness: The cost effectiveness is \$228 per ton HN3 reduced. (1999\$)

Comments:

Status: Demonstrated

Last Reviewed: 2000

Additional Information:

References:

Axe, 1999: D. Axe, IMC Agrico Feed Ingredients, personal communication with S. Roe, E.H. Pechan & Associates, Inc., June 1999.

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Hog Operations

Control Measure Name: Chemical Additives to Waste

Rule Name: Not Applicable

Pechan Measure Code: A00301

POD: 03

Application: This control is the adding of chemicals to hog waste to reduce ammonia emissions from hog feedlots. Assessment of control measures applicable to ammonia emissions for hog operations is based on procedures used for cattle operations.

The control applies to all hog and pig operations classified under SCC 2805025000.

Affected SCC:

2805025000 Hogs and Pigs Composite, Total

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
								√*		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 50% from uncontrolled

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Pechan contacted the manufacturer of the chemical inhibitor, N-(n-butyl) thiophosphoric triamide (NBPT; trade name Conserve-Nr). According to the manufacturer, the control effectiveness at cattle feedlots is 50 percent and the cost per head-day is \$0.0062 (\$2.26/head-yr; Axe, 1999).

According to the manufacturer, the same 50 percent control efficiency derived for cattle can be assumed for hogs (Axe, 1999). The emission factor for hogs is 20.3 lb/head-yr. With the 50 percent control efficiency, this equates to 10.15 lb/head-yr reduced (5.08 x 10⁻³ ton/head-yr reduced). Therefore, the cost parameter would be \$0.37/5.08E-3 ton or \$73/ton NH₃ reduced.

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$73 per ton NH₃ reduced. (1999\$)

Comments:

Status: Demonstrated

Last Reviewed: 1999

Additional Information:

There is assumed to be 100 percent penetration; however, the modeling parameters are probably most applicable to large hog farming operations. Hence, it may be more reasonable to apply the control in counties with large hog raising operations (i.e., using COA data).

References:

Axe, 1999: D. Axe, IMC Agrico Feed Ingredients, personal communication with S. Roe, E.H. Pechan & Associates, Inc., June 1999.

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Poultry Operations

Control Measure Name: Chemical Additives to Waste

Rule Name: Not Applicable

Pechan Measure Code: A00201

POD: 02

Application: This control is the chemical addition of alum to poultry litter. Alum is used to stabilize poultry litter to reduce ammonia emissions. Alum, an acid-forming compounds, keeps the pH of the poultry litter below 7, which inhibits ammonia volatilization.

The control applies to all poultry and chicken operations classified under SCC 280503000.

Affected SCC:

2805030000 Poultry and Chickens Composite, Total

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
								√*		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 75% from uncontrolled

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Treatment costs are estimated to be about \$0.025/head (Moore, 1999). These costs do not factor in some benefits to the grower (e.g., reduced heating/ventilation costs due to lower ammonia levels; higher value for fertilizer due to higher nitrogen levels). Assuming six grow-outs per year, the costs would be \$0.15/head-yr. The emission factor used for all poultry is 0.394 lb/head-yr (1.97 x 10⁻⁴ ton/head-yr). Assuming a 75 percent control efficiency for alum treatment, the emission reduction would be 1.48 x 10⁻⁴ ton/head-yr reduced. Hence, the cost parameter would be \$0.15/1.48E-04 ton reduced or \$1,014/ton NH₃ reduced.

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$1,014 per ton NH₃ reduced. (1999\$)

Comments:

Status: Demonstrated

Last Reviewed: 1999

Additional Information:

The control effectiveness for alum treatment is estimated to be 75 percent (Moore, 1999). The control effectiveness is highest during the early part of the growing cycle (i.e., >95 percent), when the young chickens are most susceptible to health problems from high ammonia levels. The control effectiveness drops off during the grow-out (about two months). Alum is then reapplied to the litter before the next grow-out begins (typically, there are 5 or 6 grow-outs per year). There is assumed to be 100 percent penetration.

AT-A-GLANCE TABLE FOR AREA SOURCES

References:

Axe, 1999: D. Axe, IMC Agrico Feed Ingredients, personal communication with S. Roe, E.H. Pechan & Associates, Inc., June 1999

Moore, 1999: P.A. Moore, Jr., University of Arkansas, personal communication with S. Roe, E.H. Pechan & Associates, Inc., June 1999

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Agricultural Burning

Control Measure Name: Seasonal Ban (Ozone Season Daily)

Rule Name: Not Applicable

Pechan Measure Code: N13201

POD: 132

Application: An ozone season ban of burning is a ban of burning on an ozone season day where ozone exceedances are predicted. Ozone season daily ban of agricultural burning to reduce NOx emissions during the ban.

This control is applicable to field burning where the entire field would be set on fire, and can be applied to all crop types. These sources are classified under 2801500000.

Affected SCC:

2801500000 Agricultural Burning

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√/*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: Daily control efficiency is 100% from uncontrolled; Annual control efficiency is 0% from uncontrolled

Equipment Life: Not Applicable

Rule Effectiveness: 80%

Penetration: 100%

Cost Basis: Since burning can simply be shifted to other acceptable periods, emission control costs are assumed to be zero for regulations that schedule the burning days where ozone exceedances are not predicted (Pechan, 1997).

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$0 per ton NOx reduced (1990\$).

Note: Since this is a daily control, no annual emission reductions are expected.

Comments:

Status: Demonstrated

Last Reviewed: 1997

Additional Information:

Costs may be incurred if personnel scheduled to participate in the agricultural burning cannot be used elsewhere or if fire personnel or other professionals have been scheduled to participate.

Assuming full compliance with the regulation, ozone season daily emission reductions from such a regulation would be 100 percent. However, annual emission reductions would not be expected, because there would likely be a shift in the timing of the emissions, not a reduction in the total amount of annual NOx emitted. A compliance rate of 80 percent is used in estimating daily reductions (Pechan, 1997).

AT-A-GLANCE TABLE FOR AREA SOURCES

References:

Pechan, 1997: E.H. Pechan & Associates, "Additional Control Measure Evaluation for the Integrated Implementation of the Ozone and Particulate Matter National Ambient Air Quality Standards, and Regional Haze Program," prepared for U.S. Environmental Protection Agency, July 1997.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Ammonia - Natural Gas - Fired Reformers - Small Sources

Control Measure Name: Low NOx Burner

Rule Name: Not Applicable

Pechan Measure Code: N0561S, N05601

POD: 56

Application: This control is the use of low NOx burner (LNB) technology to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another.

This control is applicable to small (<1 ton NOx per OSD) ammonia production operations with natural gas-fired reformers (SCC 30100306) and uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

30100306 Ammonia Production, Primary Reformer: Natural Gas Fired

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 50% from uncontrolled

Equipment Life: 10 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NOx emission levels (Pechan, 1998).

Small source = emissions level less than 1 ton per ozone season day

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned along with a capital to annual costs ratio of 5.5. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 10 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 70% (Pechan, 2001).

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$820 per ton NOx reduced from both uncontrolled and RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 1998

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNBs create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNBs create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Industrial/Commercial/Institutional (ICI) Boilers," EPA,-453/R-94-022, Research Triangle Park, NC, June 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Ammonia - Natural Gas - Fired Reformers - Small Sources

Control Measure Name: Low NOx Burner (LNB) + Flue Gas Recirculation (FGR)

Rule Name: Not Applicable

Pechan Measure Code: N0562S, N05602

POD: 56

Application: This control is the use of low NOx burner (LNB) technology and flue gas recirculation (FGR) to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another.

This control is applicable to small (<1 ton NOx per OSD) ammonia production operations with natural gas-fired reformers (SCC 30100306) and uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

30100306 Ammonia Production, Primary Reformer: Natural Gas Fired

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 60% from uncontrolled

Equipment Life: 10 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NOx emission levels (Pechan, 1998).

Small source = emissions level less than 1 ton per ozone season day

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). The basis of the costs are model plant data for mechanical draft heaters firing natural gas and oil contained in the Alternative Control Techniques (ACT) document (EPA, 1993). From this analysis, default cost per ton values are assigned along with a capital to annual costs ratio of 5.9. An equipment life of 10 years is assumed (EPA, 1993).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 70% (Pechan, 2001).

Cost Effectiveness: The default cost effectiveness values are \$2,560 per ton NOx reduced from uncontrolled and \$2,470 per ton NOx reduced from RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNBs create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNBs create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Industrial/Commercial/Institutional (ICI) Boilers," EPA,-453/R-94-022, Research Triangle Park, NC, June 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Ammonia - Natural Gas - Fired Reformers - Small Sources

Control Measure Name: Oxygen Trim + Water Injection

Rule Name: Not Applicable

Pechan Measure Code: N0563S, N05603

POD: 56

Application: This control is the use of OT + WI to reduce NOx emissions.

This control is applicable to small (<1 ton NOx per OSD) ammonia production operations with natural gas-fired reformers (SCC 30100306) and uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

30100306 Ammonia Production, Primary Reformer: Natural Gas Fired

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 65% from uncontrolled

Equipment Life: 10 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by power output (Pechan, 1998).

Small source = less than 1 ton NOx per ozone season day

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). The basis of the costs are model plant data in the Alternative Control Techniques (ACT) document (EPA, 1994). From this analysis, default cost per ton values are assigned along with a capital to annual costs ratio of 2.9. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 10 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 70% (Pechan, 2001).

Cost Effectiveness: The default cost effectiveness value is \$680 per ton NOx reduced from both uncontrolled and RACT baselines (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

Water is injected into the gas turbine, reducing the temperatures in the NOx-forming regions. The water can be injected into the fuel, the combustion air or directly into the combustion chamber (ERG, 2000).

AT-A-GLANCE TABLE FOR POINT SOURCES

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Industrial/Commercial/Institutional (ICI) Boilers," EPA-453/R-94-022, Research Triangle Park, NC, June 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

ERG, 2000: Eastern Research Group, Inc., "How to Incorporate the Effects of Air Pollution Control Device Efficiencies and Malfunctions into Emission Inventory Estimates," prepared for Emission Inventory Improvement Program, Point Sources Committee, July 2000.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Ammonia - Natural Gas - Fired Reformers - Small Sources

Control Measure Name: Selective Catalytic Reduction (SCR)

Rule Name: Not Applicable

Pechan Measure Code: N0564S, N05604

POD: 56

Application: This control is the selective catalytic reduction of NO_x through add-on controls. SCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NO_x) into molecular nitrogen (N₂) and water vapor (H₂O). The SCR utilizes a catalyst to increase the NO_x removal efficiency, which allows the process to occur at lower temperatures.

Applies to small (<1 ton NO_x per OSD) natural-gas fired reformers involved in the production of ammonia (SCC 30100306) with uncontrolled NO_x emissions greater than 10 tons per year..

Affected SCC:

30100306 Ammonia Production, Primary Reformer: Natural Gas Fired

Pollutant(s)	PM10	PM2.5	EC	OC	NO _x	VOC	SO ₂	NH ₃	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 80% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NO_x emission levels (Pechan, 1998).

Small source = emission levels less than 1 ton per ozone season day

Costs for stationary source NO_x control are based on an analysis of EPA's NO_x State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 20 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 70% (Pechan, 2001).

Cost Effectiveness: The cost effectiveness values used in AirControlNET are \$2,230 per ton NO_x reduced from uncontrolled and \$2,860 per ton NO_x reduced from RACT baseline (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

Selective Catalytic Reduction (SCR) has been widely applied to stationary source, fossil fuel-fired, combustion units for emission control since the early 1970s. SCR is typically implemented on units requiring a higher level of NO_x control than achievable by SNCR or other combustion controls (EPA, 2002).

Like SNCR, SCR is based on the chemical reduction of the NO_x molecule. The primary difference between SNCR and SCR is that SCR uses a metal-based catalyst to increase the rate of reaction (EPA, 2002). A nitrogen based reducing reagent, such as ammonia or urea, is injected into the flue gas. The reagent reacts selectively with the flue gas NO_x within a specific temperature range and in the presence of the catalyst and oxygen to reduce the NO_x.

The use of a catalyst results in two advantages of the SCR process over SNCR, the higher NO_x reduction efficiency and the lower and broader temperature ranges. However, the decrease in reaction temperature and increase in efficiency is accompanied by a significant increase in capital and operating costs (EPA, 2002). The cost increase is due to the large amount of catalyst required.

The SCR system can utilize either aqueous or anhydrous ammonia as the reagent. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Today, catalyst formulations include single component, multi-component, or active phase with a support structure. Most catalyst formulations contain additional compounds or supports, providing thermal and structural stability or to increase surface area (EPA, 2002).

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include: reaction temperature range; residence time available in the optimum temperature range; degree of mixing between the injected reagent and the combustion gases; uncontrolled NO_x concentration level; molar ratio of injected reagent to uncontrolled NO_x; ammonia slip; catalyst activity; catalyst selectivity; pressure drop across the catalyst; catalyst pitch; catalyst deactivation; and catalyst management (EPA, 2001).

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Industrial/Commercial/Institutional (ICI) Boilers," EPA-453/R-94-022, Research Triangle Park, NC, June 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection

AT-A-GLANCE TABLE FOR POINT SOURCES

Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Ammonia - Natural Gas - Fired Reformers - Small Sources

Control Measure Name: Selective Non-Catalytic Reduction (SNCR)

Rule Name: Not Applicable

Pechan Measure Code: N0565S, N05605

POD: 56

Application: This control is the reduction of NO_x emission through selective non-catalytic reduction add-on controls. SNCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NO_x) into molecular nitrogen (N₂) and water vapor (H₂O).

This control applies to small (<1 ton NO_x per OSD) ammonia production natural gas fired reformers (SCC 30100306) with uncontrolled NO_x emissions greater than 10 tons per year.

Affected SCC:

30100306 Ammonia Production, Primary Reformer: Natural Gas Fired

Pollutant(s)	PM10	PM2.5	EC	OC	NO _x	VOC	SO ₂	NH ₃	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 50% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NO_x emission levels (Pechan, 1998).

Small source = emission levels less than 1 ton per ozone season day

Costs for stationary source NO_x control are based on an analysis of EPA's NO_x State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 20 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 70% (Pechan, 2001).

Cost Effectiveness: The cost effectiveness values used in AirControlNET are \$3,780 per ton NO_x reduced from uncontrolled and \$2,900 per ton NO_x reduced from RACT baseline (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

SNCR is the reduction of NO_x in flue gas to N₂ and water vapor. This reduction is done with a nitrogen based reducing reagent, such as ammonia or urea. The reagent can react with a number of flue gas components. However, the NO_x reduction reaction is favored for a specific temperature range and in the presence of oxygen (EPA, 2002).

Both ammonia and urea are used as reagents. The cost of the reagent represents a large part of the annual costs of an SNCR system. Ammonia is generally less expensive than urea. However, the choice of reagent is also based on physical properties and operational considerations (EPA, 2002).

Ammonia can be utilized in either aqueous or anhydrous form. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Urea based systems have several advantages, including several safety aspects. Urea is a nontoxic, less volatile liquid that can be stored and handled more safely than ammonia. Urea solution droplets can penetrate farther into the flue gas when injected into the boiler, enhancing mixing (EPA, 2002). Because of these advantages, urea is more commonly used than ammonia in large boiler applications.

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include:

Reaction temperature range;
Residence time available in the optimum temperature range;
Degree of mixing between the injected reagent and the combustion gases
Uncontrolled NO_x concentration level;
Molar ratio of injected reagent to uncontrolled NO_x ; and
Ammonia slip.

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Industrial/Commercial/Institutional (ICI) Boilers," EPA-453/R-94-022, Research Triangle Park, NC, June 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Ammonia Products; Feedstock Desulfurization - Small Sources

Control Measure Name: Low NOx Burner + Flue Gas Recirculation

Rule Name: Not Applicable

Pechan Measure Code: N0622S, N06202

POD: 62

Application: This control is the use of low NOx burner (LNB) technology and flue gas recirculation (FGR) to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another.

This control is applicable to small (<1 ton per OSD) feedstock desulfurization processes in ammonia products operations with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

30100305 Ammonia Production, Feedstock Desulfurization

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 60% from uncontrolled

Equipment Life: 10 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by power output (Pechan, 1998).

Small source = less than 1 ton NOx per ozone season day

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). The basis of the costs are model plant data in the Alternative Control Techniques (ACT) document (EPA, 1994). From this analysis, default cost per ton values are assigned along with a capital to annual costs ratio of 5.9. An equipment life of 10 years is assumed (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 70% (Pechan, 2001).

Cost Effectiveness: The default cost effectiveness values are \$2,560 per ton NOx reduced from uncontrolled and \$2,470 per ton NOx reduced from RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

It is assumed that the superheated steam needed to regenerate the activated carbon bed used in the desulfurization process is the NO_x source.

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNBs create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNBs create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Industrial/Commercial/Institutional (ICI) Boilers," EPA-453/R-94-022, Research Triangle Park, NC, June 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Asphaltic Conc; Rotary Dryer; Conv Plant - Small Sources

Control Measure Name: Low NOx Burner

Rule Name: Not Applicable

Pechan Measure Code: N0731S, N0730I

POD: 73

Application: This control is the use of low NOx burner (LNB) technology to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another.

This control is applicable to small (<1 ton NOx per OSD) construction operations with rotary driers and uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

30502508 Construction Sand & Gravel, Dryer (See 3-05-027-20 thru -24 Industrial Sand Dryers)

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 50% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NOx emission levels (Pechan, 1998).

Small source = emissions level less than 1 ton per ozone season day

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned along with a capital to annual costs ratio of 7.3. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 15 years (EPA, 1993).

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$2,200 per ton NOx reduced from both uncontrolled and RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 1998

Additional Information:

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNBs create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNBs create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

AT-A-GLANCE TABLE FOR POINT SOURCES

References:

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Process Heaters," EPA-453/R-93-034, Research Triangle Park, NC, September 1993.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: By-Product Coke Manufacturing; Oven Underfiring

Control Measure Name: Selective Non-Catalytic Reduction (SNCR)

Rule Name: Not Applicable

Pechan Measure Code: N0653S, N06503

POD: 65

Application: This control is the reduction of NO_x emission through selective non-catalytic reduction add-on controls. SNCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NO_x) into molecular nitrogen (N₂) and water vapor (H₂O).

This control applies to all by-product coke manufacturing operations with oven underfiring (SCC 30300306) and uncontrolled NO_x emissions greater than 10 tons per year.

Affected SCC:

30300306 By-product Coke Manufacturing, Oven Underfiring

Pollutant(s)	PM10	PM2.5	EC	OC	NO _x	VOC	SO ₂	NH ₃	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 60% from uncontrolled

Equipment Life: 10 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NO_x emission levels (Pechan, 1998).

Small source = emission levels less than 1 ton per ozone season day

Large source = emission levels greater than 1 ton per ozone season day

Costs for stationary source NO_x control are based on an analysis of EPA's NO_x State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 10 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than 70% (Pechan, 2001).

Cost Effectiveness: The cost effectiveness (for both small and large sources) used in AirControlNET for both reductions from baseline and reductions from RACT is \$1,640 per ton NO_x reduced (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

SNCR is the reduction of NO_x in flue gas to N₂ and water vapor. This reduction is done with a nitrogen based reducing reagent, such as ammonia or urea. The reagent can react with a number of flue gas components. However, the NO_x reduction reaction is favored for a specific temperature range and in the presence of oxygen (EPA, 2002).

Both ammonia and urea are used as reagents. The cost of the reagent represents a large part of the annual costs of an SNCR system. Ammonia is generally less expensive than urea. However, the choice of reagent is also based on physical properties and operational considerations (EPA, 2002).

Ammonia can be utilized in either aqueous or anhydrous form. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Urea based systems have several advantages, including several safety aspects. Urea is a nontoxic, less volatile liquid that can be stored and handled more safely than ammonia. Urea solution droplets can penetrate farther into the flue gas when injected into the boiler, enhancing mixing (EPA, 2002). Because of these advantages, urea is more commonly used than ammonia in large boiler applications.

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include:

Reaction temperature range;
Residence time available in the optimum temperature range;
Degree of mixing between the injected reagent and the combustion gases
Uncontrolled NO_x concentration level;
Molar ratio of injected reagent to uncontrolled NO_x ; and
Ammonia slip.

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Iron and Steel Mills," EPA-453/R-94-065, Research Triangle Park, NC, September, 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Cement Kilns

Control Measure Name: Biosolid Injection

Rule Name: Not Applicable

Pechan Measure Code: NCEMK

POD: 90

Application: This control applies to cement kilns

Affected SCC:

30102306 Sulfuric Acid (Contact Process), Absorber/@99.0% Conversion

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 23% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Capital cost to annual ratio is 7.3

Cost Effectiveness: The cost effectiveness is \$310 per ton of Nox reduction (1997\$).

Comments:

Status: Demonstrated

Last Reviewed: 2004

Additional Information:

References:

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Cement Manufacturing - Dry

Control Measure Name: Mid-Kiln Firing

Rule Name: Not Applicable

Pechan Measure Code: N0331L, N0331S, N03301

POD: 33

Application: This control is the use of mid- kiln firing to reduce NOx emissions.

This control applies to dry-process cement manufacturing (SCC 30500606) with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

30500606 Mineral Products, Cement Manufacturing (Dry Process), Kilns

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 25% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Cost equations for cement plants NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). Capital and annual cost information was obtained from a NOx control technologies for the cement industry report (EC/R, 2000). Cost for low-NOx burners were developed using model plants. A discount rate of 10% and an equipment life of 15 years was assumed.

O&M Cost Components: The O&M cost breakdown is estimated using the detailed information in the EC/R report, Tables 6-3, 6-9 and 6-10. Per the EC/R report, electricity costs are negligible. The breakdown was obtained using the average O&M costs for furnaces having capacities of 113 and 180 MMBTU per hour. A capacity factor of is used in estimating the O&M cost breakdown.

Maintenance labor: \$24.33 per hour times 0.5 hour per 8-hour shift

Fuel (tires): -\$42.50 per ton

Cost Effectiveness: The default cost effectiveness value is \$55 per ton NOx reduced from both uncontrolled and RACT baselines (1997\$). The cost effectiveness range is from a savings of \$460 to a cost of \$720 per ton NOx reduced.

Comments:

Status: Demonstrated

Last Reviewed: 1998

Additional Information:

AT-A-GLANCE TABLE FOR POINT SOURCES

References:

EC/R, 2000: EC/R Incorporated, "NOx Control Technologies for the Cement Industry," prepared for U.S. Environmental Protection Agency, Research Triangle Park, NC, September 2000.

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Cement Manufacturing," EPA-453/R-94-004, Research Triangle Park, NC, March 1994.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Cement Manufacturing - Dry

Control Measure Name: Low NOx Burner

Rule Name: Not Applicable

Pechan Measure Code: N0332S, N03302

POD: 33

Application: This control is the use of low NOx burner (LNB) technology to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another.

This control applies to dry-process cement manufacturing operations with indirect-fired kilns (SCC 30500606) with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

30500606 Mineral Products, Cement Manufacturing (Dry Process), Kilns

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 25% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). Capital and annual cost information was obtained from a NOx control technologies for the cement industry report (EC/R, 2000). Cost for low-NOx burners were developed using model plants. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 15 years (EPA, 1994).

O&M Cost Components: The O&M cost breakdown is estimated using the detailed information in Tables 6-5, 6-6, 6-7 and 6-8 of the ACT document. The breakdown was developed using the average costs for 2 direct-fired and 2 indirect-fired model furnaces. A capacity factor of 0.91 is used in estimating the O&M cost breakdown.

Operating Labor: \$22.12/hr

Maintenance Labor: \$24.33/hr

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$440 per ton NOx reduced from both uncontrolled and RACT (1997\$). The cost effectiveness range is \$300 to \$620 per ton NOx reduced.

Comments:

Status: Demonstrated

Last Reviewed: 1998

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNBs create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNBs create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

References:

EC/R, 2000: EC/R Incorporated, "NOx Control Technologies for the Cement Industry," prepared for U.S. Environmental Protection Agency, Research Triangle Park, NC, September 2000.

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Cement Manufacturing," EPA,-453/R-94-004, Research Triangle Park, NC, March 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 1998.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Cement Manufacturing - Dry

Control Measure Name: Selective Non-Catalytic Reduction (SNCR) Urea Based

Rule Name: Not Applicable

Pechan Measure Code: N0333S, N03303

POD: 33

Application: This control is the reduction of NO_x emission through urea based selective non-catalytic reduction add-on controls. SNCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NO_x) into molecular nitrogen (N₂) and water vapor (H₂O).

This control applies to dry-process cement manufacturing (SCC 30500606) with uncontrolled NO_x emissions greater than 10 tons per year.

Affected SCC:

30500606 Mineral Products, Cement Manufacturing (Dry Process), Kilns

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 50% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NO_x emission levels (Pechan, 1998).

Small source = emission levels less than 1 ton per ozone season day

Large source = emission levels greater than 1 ton per ozone season day

Costs for stationary source NO_x control are based on an analysis of EPA's NO_x State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned for small sources. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 15 years (EPA, 1994).

O&M Cost Components: The O&M cost breakdown is estimated using the detailed information in the ACT document Table 6-11. The breakdown was obtained using the average O&M costs for furnaces having capacities of 152, 266, 330 and 495 MMBTU per hour. A capacity factor of 0.913 is used in estimating the O&M cost breakdown.

Operating labor: \$28.22 per hour

Maintenance labor: \$24.33 per hour times 0.5 hours per 8 hour shift

Cost Effectiveness: The cost effectiveness (for both small and large sources) used in AirControlNET for both reductions from baseline and reductions from RACT is \$770 per ton NO_x reduced (1990\$).

Comments:

AT-A-GLANCE TABLE FOR POINT SOURCES

Status: Demonstrated	Last Reviewed: 1998
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Additional Information:

SNCR is the reduction of NO_x in flue gas to N₂ and water vapor. This reduction is done with a nitrogen based reducing reagent, such as ammonia or urea. The reagent can react with a number of flue gas components. However, the NO_x reduction reaction is favored for a specific temperature range and in the presence of oxygen (EPA, 2002).

Urea based systems have several advantages, including several safety aspects. Urea is a nontoxic, less volatile liquid that can be stored and handled more safely than ammonia. Urea solution droplets can penetrate farther into the flue gas when injected into the boiler, enhancing mixing (EPA, 2002). Because of these advantages, urea is more commonly used than ammonia in large boiler applications.

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include:

Reaction temperature range;
Residence time available in the optimum temperature range;
Degree of mixing between the injected reagent and the combustion gases
Uncontrolled NO_x concentration level;
Molar ratio of injected reagent to uncontrolled NO_x ; and
Ammonia slip.

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Cement Manufacturing," EPA,-453/R-94-004, Research Triangle Park, NC, March 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Cement Manufacturing - Dry

Control Measure Name: Selective Non-Catalytic Reduction (SNCR) Ammonia Based

Rule Name: Not Applicable

Pechan Measure Code: N0334S, N03304

POD: 33

Application: This control is the reduction of NO_x emission through ammonia based selective non-catalytic reduction add-on controls. SNCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NO_x) into molecular nitrogen (N₂) and water vapor (H₂O).

This control applies to dry-process cement manufacturing operations (SCC 30500606) with uncontrolled NO_x emissions greater than 10 tons per year.

Affected SCC:

30500606 Mineral Products, Cement Manufacturing (Dry Process), Kilns

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 50% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NO_x emission levels (Pechan, 1998).

Small source = emission levels less than 1 ton per ozone season day

Large source = emission levels greater than 1 ton per ozone season day

Costs for stationary source NO_x control are based on an analysis of EPA's NO_x State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned for small sources. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 15 years (EPA, 1994).

O&M Cost Components: The O&M cost breakdown is estimated using the detailed information in . The breakdown was obtained using the average O&M costs for having capacities of per hour. A capacity factor of is used in estimating the O&M cost breakdown.

Operating labor: \$28.22 per hour

Fuel (natural gas): \$5.00 per MMBTU

Cost Effectiveness: The cost effectiveness (for both small and large sources) used in AirControlNET for both reductions from baseline and reductions from RACT is \$850 per ton NO_x reduced (1990\$).

Comments:

AT-A-GLANCE TABLE FOR POINT SOURCES

Status: Demonstrated	Last Reviewed: 1998
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Additional Information:

SNCR is the reduction of NO_x in flue gas to N₂ and water vapor. This reduction is done with a nitrogen based reducing reagent, such as ammonia or urea. The reagent can react with a number of flue gas components. However, the NO_x reduction reaction is favored for a specific temperature range and in the presence of oxygen (EPA, 2002).

Both ammonia and urea are used as reagents. The cost of the reagent represents a large part of the annual costs of an SNCR system. Ammonia is generally less expensive than urea. However, the choice of reagent is also based on physical properties and operational considerations (EPA, 2002).

Ammonia can be utilized in either aqueous or anhydrous form. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Urea based systems have several advantages, including several safety aspects. Urea is a nontoxic, less volatile liquid that can be stored and handled more safely than ammonia. Urea solution droplets can penetrate farther into the flue gas when injected into the boiler, enhancing mixing (EPA, 2002). Because of these advantages, urea is more commonly used than ammonia in large boiler applications.

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include:

Reaction temperature range;
Residence time available in the optimum temperature range;
Degree of mixing between the injected reagent and the combustion gases
Uncontrolled NO_x concentration level;
Molar ratio of injected reagent to uncontrolled NO_x ; and
Ammonia slip.

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Cement Manufacturing," EPA,-453/R-94-004, Research Triangle Park, NC, March 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Cement Manufacturing - Dry

Control Measure Name: Selective Catalytic Reduction (SCR)

Rule Name: Not Applicable

Pechan Measure Code: N0335S, N03305

POD: 33

Application: This control is the selective catalytic reduction of NO_x through add-on controls. SCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NO_x) into molecular nitrogen (N₂) and water vapor (H₂O). The SCR utilizes a catalyst to increase the NO_x removal efficiency, which allows the process to occur at lower temperatures.

This control applies to dry-process cement manufacturing (SCC 30500606) with uncontrolled NO_x emissions greater than 10 tons per year.

Affected SCC:

30500606 Mineral Products, Cement Manufacturing (Dry Process), Kilns

Pollutant(s)	PM10	PM2.5	EC	OC	NO _x	VOC	SO ₂	NH ₃	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 80% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NO_x emission levels (Pechan, 1998).

Small source = emission levels less than 1 ton per ozone season day

Large source = emission levels greater than 1 ton per ozone season day

Costs for stationary source NO_x control are based on an analysis of EPA's NO_x State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 15 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than 70% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown is estimated using the detailed information in the EC/R report, Tables 6-13 and 6-14. The breakdown was obtained using the average O&M costs for furnaces having capacities of 113 and 180 MMBTU per hour. A capacity factor of 0.913 is used in estimating the O&M cost breakdown.

Operating labor: \$22.12 per hour

Maintenance labor: \$24.33 per hour

Cost Effectiveness: The cost effectiveness values (for both small and large sources) used in

AT-A-GLANCE TABLE FOR POINT SOURCES

AirControlNET are \$3,370 per ton NO_x reduced from both uncontrolled and RACT baselines (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

Selective Catalytic Reduction (SCR) has been widely applied to stationary source, fossil fuel-fired, combustion units for emission control since the early 1970s. SCR is typically implemented on units requiring a higher level of NO_x control than achievable by SNCR or other combustion controls (EPA, 2002).

Like SNCR, SCR is based on the chemical reduction of the NO_x molecule. The primary difference between SNCR and SCR is that SCR uses a metal-based catalyst to increase the rate of reaction (EPA, 2002). A nitrogen based reducing reagent, such as ammonia or urea, is injected into the flue gas. The reagent reacts selectively with the flue gas NO_x within a specific temperature range and in the presence of the catalyst and oxygen to reduce the NO_x.

The use of a catalyst results in two advantages of the SCR process over SNCR, the higher NO_x reduction efficiency and the lower and broader temperature ranges. However, the decrease in reaction temperature and increase in efficiency is accompanied by a significant increase in capital and operating costs (EPA, 2002). The cost increase is due to the large amount of catalyst required.

The SCR system can utilize either aqueous or anhydrous ammonia as the reagent. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Today, catalyst formulations include single component, multi-component, or active phase with a support structure. Most catalyst formulations contain additional compounds or supports, providing thermal and structural stability or to increase surface area (EPA, 2002).

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include: reaction temperature range; residence time available in the optimum temperature range; degree of mixing between the injected reagent and the combustion gases; uncontrolled NO_x concentration level; molar ratio of injected reagent to uncontrolled NO_x; ammonia slip; catalyst activity; catalyst selectivity; pressure drop across the catalyst; catalyst pitch; catalyst deactivation; and catalyst management (EPA, 2001).

References:

EC/R, 2000: EC/R Incorporated, "NO_x Control Technologies for the Cement Industry," prepared for U.S. Environmental Protection Agency, Research Triangle Park, NC, September 2000.

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Cement Manufacturing," EPA-453/R-94-004, Research Triangle Park, NC, March 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

AT-A-GLANCE TABLE FOR POINT SOURCES

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Cement Manufacturing - Wet

Control Measure Name: Mid-Kiln Firing

Rule Name: Not Applicable

Pechan Measure Code: N0341L, N0341S, N03401

POD: 34

Application: This control is the use of mid- kiln firing to reduce NOx emissions.

This control applies to wet-process cement manufacturing (SCC 30500706) with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

30500706 Mineral Products, Cement Manufacturing (Wet Process), Kilns

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 25% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Cost equations for cement plants NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). Capital and annual cost information was obtained from a NOx control technologies for the cement industry report (EC/R, 2000). Cost for low-NOx burners were developed using model plants. A discount rate of 10% and an equipment life of 15 years was assumed.

O&M Cost Components: The O&M cost breakdown is estimated using the detailed information in the EC/R report, Tables 6-3, 6-9 and 6-10. The breakdown was obtained using the average costs for furnaces having capacities of 113 and 180 MMBTU per hour. A capacity factor of 0.913 is used in estimating the O&M cost breakdown.

Maintenance labor: \$24.33 per hour

Fuel (tires): -\$42.50 per ton

Cost Effectiveness: The default cost effectiveness value is \$55 per ton NOx reduced from both uncontrolled and RACT baselines (1997\$). The cost effectiveness range is from a savings of \$460 to a cost of \$720 per ton NOx reduced.

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

AT-A-GLANCE TABLE FOR POINT SOURCES

References:

EC/R, 2000: EC/R Incorporated, "NOx Control Technologies for the Cement Industry," prepared for U.S. Environmental Protection Agency, Research Triangle Park, NC, September 2000.

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Cement Manufacturing," EPA,-453/R-94-004, Research Triangle Park, NC, March 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Cement Manufacturing - Wet

Control Measure Name: Low NOx Burner

Rule Name: Not Applicable

Pechan Measure Code: N0342S, N0342L, N03402

POD: 34

Application: This control is the use of low NOx burner (LNB) technology to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another.

This control applies to wet-process cement manufacturing operations with indirect-fired kilns (SCC 30500706) with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

30500706 Mineral Products, Cement Manufacturing (Wet Process), Kilns

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 25% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). Capital and annual cost information was obtained from a NOx control technologies for the cement industry report (EC/R, 2000). A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 15 years (EPA, 1994).

O&M Cost Components: The O&M cost breakdown is estimated using the detailed information in the EC/R report, Tables 6-5, 6-6, 6-7 and 6-8. The breakdown was obtained using the average costs for two direct and two indirect-fired furnaces having capacities (1 direct and 1 indirect) of 180 and 300 MMBTU per hour. A capacity factor of 0.913 is used in estimating the O&M cost breakdown.

Operating labor: \$22.12/hr

Maintenance labor: \$24.33 per hour times 0.5 hours per 8 hour shift

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$440 per ton NOx reduced from both uncontrolled and RACT (1997\$). The cost effectiveness range is \$300 to \$620 per ton NOx reduced.

Comments:

Status: Demonstrated

Last Reviewed: 1998

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

LNBS are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNBS create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNBS create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

References:

EC/R, 2000: EC/R Incorporated, "NOx Control Technologies for the Cement Industry," prepared for U.S. Environmental Protection Agency, Research Triangle Park, NC, September 2000.

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Cement Manufacturing," EPA,-453/R-94-004, Research Triangle Park, NC, March 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 1998.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Cement Manufacturing - Wet - Large Sources

Control Measure Name: Selective Catalytic Reduction (SCR)

Rule Name: Not Applicable

Pechan Measure Code: N0343L, N03403

POD: 34

Application: This control is the selective catalytic reduction of NOx through add-on controls. SCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NOx) into molecular nitrogen (N₂) and water vapor (H₂O). The SCR utilizes a catalyst to increase the NOx removal efficiency, which allows the process to occur at lower temperatures.

This control applies to large(>1 ton NOx per OSD) wet-process cement manufacturing (SCC 30500706) with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

30500706 Mineral Products, Cement Manufacturing (Wet Process), Kilns

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 80% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NOx emission levels (Pechan, 1998).

Large source = emission levels greater than 1 ton per ozone season day

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 15 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than 70% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown is estimated using the detailed information in the EC/R report Tables 6-3, 6-13 and 6-14. The breakdown was obtained using the average costs for furnaces having capacities of 113 and 180 MMBTU per hour. A capacity factor of 0.913 is used in estimating the O&M cost breakdown.

Operating labor: \$22.12/hr

Maintenance labor: \$24.33/hr

Fuel (natural gas): \$3.42/MMBTU

Cost Effectiveness: The cost effectiveness values (for both small and large sources) used in

AT-A-GLANCE TABLE FOR POINT SOURCES

AirControlNET are \$2,880 per ton NO_x reduced from both uncontrolled and RACT baselines (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

Selective Catalytic Reduction (SCR) has been widely applied to stationary source, fossil fuel-fired, combustion units for emission control since the early 1970s. SCR is typically implemented on units requiring a higher level of NO_x control than achievable by SNCR or other combustion controls (EPA, 2002).

Like SNCR, SCR is based on the chemical reduction of the NO_x molecule. The primary difference between SNCR and SCR is that SCR uses a metal-based catalyst to increase the rate of reaction (EPA, 2002). A nitrogen based reducing reagent, such as ammonia or urea, is injected into the flue gas. The reagent reacts selectively with the flue gas NO_x within a specific temperature range and in the presence of the catalyst and oxygen to reduce the NO_x.

The use of a catalyst results in two advantages of the SCR process over SNCR, the higher NO_x reduction efficiency and the lower and broader temperature ranges. However, the decrease in reaction temperature and increase in efficiency is accompanied by a significant increase in capital and operating costs (EPA, 2002). The cost increase is due to the large amount of catalyst required.

The SCR system can utilize either aqueous or anhydrous ammonia as the reagent. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Today, catalyst formulations include single component, multi-component, or active phase with a support structure. Most catalyst formulations contain additional compounds or supports, providing thermal and structural stability or to increase surface area (EPA, 2002).

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include: reaction temperature range; residence time available in the optimum temperature range; degree of mixing between the injected reagent and the combustion gases; uncontrolled NO_x concentration level; molar ratio of injected reagent to uncontrolled NO_x; ammonia slip; catalyst activity; catalyst selectivity; pressure drop across the catalyst; catalyst pitch; catalyst deactivation; and catalyst management (EPA, 2001).

References:

EC/R, 2000: EC/R Incorporated, "NO_x Control Technologies for the Cement Industry," prepared for U.S. Environmental Protection Agency, Research Triangle Park, NC, September 2000.

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Cement Manufacturing," EPA-453/R-94-004, Research Triangle Park, NC, March 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

AT-A-GLANCE TABLE FOR POINT SOURCES

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Cement Manufacturing - Wet - Small Sources

Control Measure Name: Selective Catalytic Reduction (SCR)

Rule Name: Not Applicable

Pechan Measure Code: N0343S

POD: 34

Application: This control is the selective catalytic reduction of NOx through add-on controls. SCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NOx) into molecular nitrogen (N₂) and water vapor (H₂O). The SCR utilizes a catalyst to increase the NOx removal efficiency, which allows the process to occur at lower temperatures.

This control applies to small (<1 ton NOx per OSD) wet-process cement manufacturing (SCC 30500706) with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

30500706 Mineral Products, Cement Manufacturing (Wet Process), Kilns

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 80% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NOx emission levels (Pechan, 1998).

Small source = emission levels less than 1 ton per ozone season day

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 15 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than 70% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown is estimated using the detailed information in the EC/R report Tables 6-3, 6-13 and 6-14. The breakdown was obtained using the average costs for furnaces having capacities of 113 and 180 MMBTU per hour. A capacity factor of 0.913 is used in estimating the O&M cost breakdown.

Operating labor: \$22.12/hr

Maintenance labor: \$24.33/hr

Cost Effectiveness: The cost effectiveness values used in AirControlNET are \$2,880 per ton NOx reduced from both uncontrolled and RACT baselines (1990\$).

AT-A-GLANCE TABLE FOR POINT SOURCES

Comments:**Status:** Demonstrated**Last Reviewed:** 2001

Additional Information:

Selective Catalytic Reduction (SCR) has been widely applied to stationary source, fossil fuel-fired, combustion units for emission control since the early 1970s. SCR is typically implemented on units requiring a higher level of NO_x control than achievable by SNCR or other combustion controls (EPA, 2002).

Like SNCR, SCR is based on the chemical reduction of the NO_x molecule. The primary difference between SNCR and SCR is that SCR uses a metal-based catalyst to increase the rate of reaction (EPA, 2002). A nitrogen based reducing reagent, such as ammonia or urea, is injected into the flue gas. The reagent reacts selectively with the flue gas NO_x within a specific temperature range and in the presence of the catalyst and oxygen to reduce the NO_x.

The use of a catalyst results in two advantages of the SCR process over SNCR, the higher NO_x reduction efficiency and the lower and broader temperature ranges. However, the decrease in reaction temperature and increase in efficiency is accompanied by a significant increase in capital and operating costs (EPA, 2002). The cost increase is due to the large amount of catalyst required.

The SCR system can utilize either aqueous or anhydrous ammonia as the reagent. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Today, catalyst formulations include single component, multi-component, or active phase with a support structure. Most catalyst formulations contain additional compounds or supports, providing thermal and structural stability or to increase surface area (EPA, 2002).

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include: reaction temperature range; residence time available in the optimum temperature range; degree of mixing between the injected reagent and the combustion gases; uncontrolled NO_x concentration level; molar ratio of injected reagent to uncontrolled NO_x; ammonia slip; catalyst activity; catalyst selectivity; pressure drop across the catalyst; catalyst pitch; catalyst deactivation; and catalyst management (EPA, 2001).

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Cement Manufacturing," EPA,-453/R-94-004, Research Triangle Park, NC, March 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter

AT-A-GLANCE TABLE FOR POINT SOURCES

Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Ceramic Clay Manufacturing; Drying - Small Sources

Control Measure Name: Low NOx Burner

Rule Name: Not Applicable

Pechan Measure Code: N0741S, N07401

POD: 74

Application: This control is the use of low NOx burner (LNB) technology to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another.

This control is applicable to small (<1 ton NOx per OSD) drying processes at ceramic clay manufacturing operations with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

30500801 Ceramic Clay/Tile Manufacture, Drying ** (use SCC 3-05-008-13)

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 50% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NOx emission levels (Pechan, 1998).

Small source = emissions level less than 1 ton per ozone season day

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). Capital and annual cost information was obtained from the Alternative Control Techniques Document (EPA, 1993). From this analysis, default cost per ton values are assigned along with a capital to annual costs ratio of 7.3. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 15 years (EPA, 1993).

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$2,200 per ton NOx reduced from both uncontrolled and RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 1998

Additional Information:

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNBs create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion

AT-A-GLANCE TABLE FOR POINT SOURCES

zone. Staged-fuel LNBs create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

References:

EPA, 1993c: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Process Heaters," EPA-453/R-93-034, Research Triangle Park, NC, September 1993.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 1998.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Coal Cleaning-Thrml Dryer; Fluidized Bed - Small Sources

Control Measure Name: Low NOx Burner

Rule Name: Not Applicable

Pechan Measure Code: N0753S, N07503

POD: 75

Application: This control is the use of low NOx burner (LNB) technology to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another.

This control is applicable to small (<1 ton NOx per OSD) thermal drying processes at coal cleaning operations with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

30502508 Construction Sand & Gravel, Dryer (See 3-05-027-20 thru -24 Industrial Sand Dryers)

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 50% from uncontrolled

Equipment Life: 10 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NOx emission levels (Pechan, 1998).

Small source = emissions level less than 1 ton per ozone season day

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned along with a capital to annual costs ratio of 4.5. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 10 years (EPA, 1994).

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$1,460 per ton NOx reduced from both uncontrolled and RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 1998

Additional Information:

Thermal dryers are a direct-heat device.

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-

AT-A-GLANCE TABLE FOR POINT SOURCES

air LNBs create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNBs create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Industrial/Commercial/Institutional (ICI) Boilers," EPA,-453/R-94-022, Research Triangle Park, NC, June 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

AT-A-GLANCE TABLE FOR UTILITY SOURCES

Source Category: Coal-fired Plants with Production Capacities>100MW

Control Measure Name: Combustion Optimization

Rule Name: Not Applicable

Pechan Measure Code: N00801

POD: 11

Application: Combustion optimization is a method that can improve combustion efficiency and decrease NOx emissions from the electric utility boilers by using active control of the combustion process. By using commercially available technology enhancements, combustion optimization is an effective and broadly applicable option for most types of boilers (e.g. gas, oil and coal) with greater than 100 MW production capacities.

This control is applicable to SCCs 10100202, 10100203, 10100212, and 10100217..

Affected SCC:

10100202 Electric Generation, Pulverized-Dry Bottom (Bituminous Coal)

10100203 Electric Generation, Bituminous/Subbituminous Coal, Cyclone Furnace (Bituminous)

10100212 Electric Generation, Pulverized Coal-Dry Bottom (Tangential) (Bituminous Coal)

10100217 Bituminous/Subbituminous Coal, Atm. Fluidized Bed Combustion-Bubbling (Bituminous)

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 20% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Based on literature surveys and discussions with vendors and other experts familiar with combustion optimization software, EPA's Integrated Planning Model (IPM) performed a cost and performance analysis for process optimization of coal plants with production capacities greater than 100 MW. According to this analysis, the capital needed for making the required modifications to the boilers and adding the required sensors, software and control devices was estimated to be \$250,000 per unit. The annual operating and maintenance costs for the control systems were estimated to be \$40,000 per boiler. This analysis, however does not take into account the projected energy savings.

Wisconsin Department of Natural Resources estimated the costs associated with three government-owned facilities in 2000 and estimated the initial expenditure for the boilers to be approximately \$100,000 each. Including expected fuel savings, the Wisconsin Department of Natural Resources estimated an annualized net savings of \$50,000 per year for each unit (WDNR, 2000).

All costs are in 1999 dollars.

Cost Effectiveness: The cost analysis is based on the 2000 Wisconsin SIP which estimated the cost effectiveness of the NOx combustion optimization to range from a cost savings of \$100 to a cost of \$50 per ton NOx reduced (1999\$). The average

AT-A-GLANCE TABLE FOR UTILITY SOURCES

value used in AirControlNET is a cost of \$50 per ton NO_x reduced. The analysis includes projected energy savings from thermal efficiency improvements for units that utilize combustion optimization (WDNR, 2000). All costs are in \$1999.

Comments:

Status: Demonstrated

Last Reviewed: 2003

Additional Information:

In coal-fired plants it is estimated that thermal efficiency can be improved by 0.5%. The improved heat rate from the units that utilize combustion optimization translates into further pollution prevention, in addition to the reduced NO_x emissions (EPA, 2002).

All combustion processes require a mixture of fuel and air. Improper fuel to air ratio can result in thermal inefficiencies and/or excessive emissions from the boilers. Combustion optimization measures seek to find and maintain optimum combustion conditions by applying better controls on the air and fuel injection mechanisms of the boilers. One approach used in process optimization utilizes a neural network computer program to find the optimum control points. For example, advanced controls, such as furnace sensors and coal flow measuring devices, can be used to optimize the boiler combustion by controlling the flow of fuel and air into the boiler (EPA, 1999).

Combustion must be optimized for the conditions that are encountered and often requires customized designs for individual boilers. For example, when boiler tubes are far enough away from the burner, computer controls from some vendors are designed to decrease the amount of air that is pre-mixed with fuel from the stoichiometric ratio to lengthen the flame at the burner and reduce the rate of heat release per unit volume (EPA, 1999).

References:

EPA, 1999: U.S. Environmental Protection Agency, Clean Air Technology Center (MD-12) Information Transfer and Program Integration Division Office of Air Quality Planning and Standard, "Nitrogen Oxides (NO_x), Why and How They Are Controlled," EPA-456/F-99-006R, Research Triangle Park, NC, November 1999.

EPA, 2002: U.S. Environmental Protection Agency, "Documentation of EPA Modeling Applications (v.2.1) Using The Integrated Planning Model," EPA 430/R-02-004, March 2002.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Combustion Turbines - Jet Fuel - Small Sources

Control Measure Name: Water Injection

Rule Name: Not Applicable

Pechan Measure Code: N0501S, N05001

POD: 50

Application: This control is the use of water injection to reduce NOx emissions.

This control applies to small (3.3 MW to 34.4MW) jet fuel-fired turbines with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

20200901 Kerosene/Naphtha (Jet Fuel), Turbine

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 68% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by the following (Pechan, 1998).

Small source = 3.3 MW to 34.4 MW

The basis of the costs are model plant data contained in the Alternative Control Techniques (ACT) document (EPA, 1993). Capital and annual cost information was obtained from control-specific cost data based on tons of glass produced. O&M costs were back calculated from annual costs. From these determinations, default cost per ton values were assigned along with a capital to annual cost ratio of 2.9 (Pechan, 1998). A discount rate of 10 percent and a capacity factor of 65 percent are assumed, along with an equipment lifetime of 15 years (EPA, 1993).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 70% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown is estimated using the information for an example small turbine in Table 6-5 of the ACT document for stationary gas turbines. The model plant is a 26.8 megawatt MS5001P turbine. Continuous operation 8,000 hours per year is used to estimate operating costs.

Electricity cost: 0.06 \$/kW-hr

Natural gas cost: \$4.13/MMBtu

Cost Effectiveness: The default cost effectiveness value is \$1,290 per ton NOx reduced from both uncontrolled and RACT baselines (1990\$).

Comments:

AT-A-GLANCE TABLE FOR POINT SOURCES

Status: Demonstrated	Last Reviewed: 2001
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Additional Information:

Water is injected into the gas turbine, reducing the temperatures in the NO_x-forming regions. The water can be injected into the fuel, the combustion air or directly into the combustion chamber (ERG, 2000).

References:

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Stationary Gas Turbines," EPA,-453/R-93-007, Research Triangle Park, NC, January 1993.

ERG, 2000: Eastern Research Group, Inc., "How to Incorporate the Effects of Air Pollution Control Device Efficiencies and Malfunctions into Emission Inventory Estimates," prepared for Emission Inventory Improvement Program, Point Sources Committee, July 2000.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Combustion Turbines - Jet Fuel - Small Sources

Control Measure Name: Selective Catalytic Reduction (SCR) + Water Injection

Rule Name: Not Applicable

Pechan Measure Code: N0502S, N05002

POD: 50

Application: This control is the selective catalytic reduction of NO_x through add-on controls in combination with water injection. SCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NO_x) into molecular nitrogen (N₂) and water vapor (H₂O). The SCR utilizes a catalyst to increase the NO_x removal efficiency, which allows the process to occur at lower temperatures.

This control applies to small (3.3 MW to 34.4MW) jet fuel-fired turbines with uncontrolled NO_x emissions greater than 10 tons per year.

Affected SCC:

20200901 Kerosene/Naphtha (Jet Fuel), Turbine

Pollutant(s)	PM10	PM2.5	EC	OC	NO _x	VOC	SO ₂	NH ₃	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 90% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by the following (Pechan, 1998).

Small source = 3.3 MW to 34.4 MW

The basis of the costs are model plant data contained in the Alternative Control Techniques (ACT) document (EPA, 1993). Capital and annual cost information was obtained from control-specific cost data based on tons of glass produced. O&M costs were back calculated from annual costs. From these determinations, default cost per ton values were assigned along with a capital to annual cost ratio of 2.8 (Pechan, 1998). A discount rate of 10 percent and a capacity factor of 65 percent are assumed, along with an equipment lifetime of 15 years (EPA, 1993).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 70% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown is estimated using the information for an example small turbine in Table 6-9 of the ACT document for stationary gas turbines. The model plant is a 26.8 megawatt MS5001P turbine. Continuous operation 8,000 hours per year is used to estimate operating costs.

Electricity cost: 0.06 \$/kW-hr

Natural gas cost: \$4.13/MMBtu

AT-A-GLANCE TABLE FOR POINT SOURCES

Cost Effectiveness: The default cost effectiveness value is \$2,30 per ton NO_x reduced from both uncontrolled and RACT baselines (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

Selective Catalytic Reduction (SCR) has been widely applied to stationary source, fossil fuel-fired, combustion units for emission control since the early 1970s. SCR is typically implemented on units requiring a higher level of NO_x control than achievable by SNCR or other combustion controls (EPA, 2002).

Like SNCR, SCR is based on the chemical reduction of the NO_x molecule. The primary difference between SNCR and SCR is that SCR uses a metal-based catalyst to increase the rate of reaction (EPA, 2002). A nitrogen based reducing reagent, such as ammonia or urea, is injected into the flue gas. The reagent reacts selectively with the flue gas NO_x within a specific temperature range and in the presence of the catalyst and oxygen to reduce the NO_x.

The use of a catalyst results in two advantages of the SCR process over SNCR, the higher NO_x reduction efficiency and the lower and broader temperature ranges. However, the decrease in reaction temperature and increase in efficiency is accompanied by a significant increase in capital and operating costs (EPA, 2002). The cost increase is due to the large amount of catalyst required.

The SCR system can utilize either aqueous or anhydrous ammonia as the reagent. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Today, catalyst formulations include single component, multi-component, or active phase with a support structure. Most catalyst formulations contain additional compounds or sup-ports, providing thermal and structural stability or to increase surface area (EPA, 2002).

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include: reaction temperature range; residence time available in the optimum temperature range; degree of mixing between the injected reagent and the combustion gases; uncontrolled NO_x concentration level; molar ratio of injected reagent to uncontrolled NO_x; ammonia slip; catalyst activity; catalyst selectivity; pressure drop across the catalyst; catalyst pitch; catalyst deactivation; and catalyst management (EPA, 2001).

References:

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Stationary Gas Turbines," EPA-453/R-93-007, Research Triangle Park, NC, January 1993.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle

AT-A-GLANCE TABLE FOR POINT SOURCES

Park, NC, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Combustion Turbines - Natural Gas - Large Sources

Control Measure Name: Dry Low NOx Combustors

Rule Name: Not Applicable

Pechan Measure Code: N0243L, N02403

POD: 24

Application: This control is the use of low NOx burner (LNB) technology to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another.

This control applies to large (83.3 MW to 161 MW) natural gas fired turbines with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

20200201 Natural Gas, Turbine

20200203 Natural Gas, Turbine: Cogeneration

20300202 Natural Gas, Turbine

20300203 Natural Gas, Turbine: Cogeneration

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 84% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by the following (Pechan, 1998).

Large source = greater than 83.3 MW and less than 161 MW

Where information was available in the Alternative Control Techniques (ACT) document (EPA, 1993), capacity-based equations are used to calculate costs. A discount rate of 10 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 15 years (EPA, 1993).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 76% (Pechan, 2001).

The following equations, based primarily on information in the Air Pollution Cost Manual (EPA, 2002), are used for large NOx sources as defined above:

From Uncontrolled:

Capital Cost = 71,281.1 * Capacity (MMBtu/hr)^{0.505}

Annual Cost = 7,826.3 * Capacity (MMBtu/hr)^{0.505}

From RACT Baseline:

AT-A-GLANCE TABLE FOR POINT SOURCES

Capital Cost = 71,281.1 * Capacity (MMBtu/hr)^{0.505}

Annual Cost = 7,826.3 * Capacity (MMBtu/hr)^{0.505}

Note: All costs are in 1990 dollars.

O&M Cost Components: There are no O&M costs associated with dry low NOx combustors.

Cost Effectiveness: When capacity is available and within the applicable range of 0 to 2,000 MMBTU/hr the cost equations are used to calculate cost effectiveness. The default cost effectiveness value, used when capacity information is not available, is \$100 per ton NOx reduced from uncontrolled and \$140 per ton NOx reduced from RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNBs create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNBs create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

References:

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Stationary Gas Turbines," EPA-453/R-93-007, Research Triangle Park, NC, January 1993.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Combustion Turbines - Natural Gas - Small Sources

Control Measure Name: Water Injection

Rule Name: Not Applicable

Pechan Measure Code: N0241S, N02401

POD: 24

Application: This control is the use of water injection to reduce NOx emissions.

This control applies to small (3.3 MW to 34.4MW) natural gas-fired gas turbines with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

20200201 Natural Gas, Turbine

20200203 Natural Gas, Turbine: Cogeneration

20300202 Natural Gas, Turbine

20300203 Natural Gas, Turbine: Cogeneration

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 76% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by the following (Pechan, 1998).

Small source = 3.3 MW to 34.4 MW

The basis of the costs are model plant data contained in the Alternative Control Techniques (ACT) document (EPA, 1993). Capital and annual cost information was obtained from control-specific cost data based on tons of glass produced. O&M costs were back calculated from annual costs. From these determinations, default cost per ton values were assigned along with a capital to annual cost ratio of 3. (Pechan, 1998). A discount rate of 10 percent and a capacity factor of 65 percent are assumed, along with an equipment lifetime of 15 years (EPA, 1993).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 76% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown is estimated using the information for an example small turbine in Table 6-5 of the ACT document for stationary gas turbines. The model plant is a 26.8 megawatt MS5001P turbine. Continuous operation 8,000 hours per year is used to estimate operating costs.

Electricity cost: 0.06 \$/kW-hr

Natural gas cost: \$4.13/MMBtu

Cost Effectiveness: The default cost effectiveness value is \$1,510 per ton NOx reduced from both

AT-A-GLANCE TABLE FOR POINT SOURCES

uncontrolled and RACT baselines (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

Water is injected into the gas turbine, reducing the temperatures in the NO_x-forming regions. The water can be injected into the fuel, the combustion air or directly into the combustion chamber (ERG, 2000).

References:

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Stationary Gas Turbines," EPA-453/R-93-007, Research Triangle Park, NC, January 1993.

ERG, 2000: Eastern Research Group, Inc., "How to Incorporate the Effects of Air Pollution Control Device Efficiencies and Malfunctions into Emission Inventory Estimates," prepared for Emission Inventory Improvement Program, Point Sources Committee, July 2000.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Combustion Turbines - Natural Gas - Small Sources

Control Measure Name: Steam Injection

Rule Name: Not Applicable

Pechan Measure Code: N0242S, N02402

POD: 24

Application: This control is the use of steam injection to reduce NOx emissions.

This control applies to small (3.3 MW to 34.4MW) natural gas-fired gas turbines with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

20200201 Natural Gas, Turbine

20200203 Natural Gas, Turbine: Cogeneration

20300202 Natural Gas, Turbine

20300203 Natural Gas, Turbine: Cogeneration

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 80% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by the following (Pechan, 1998).

Small source = 3.3 MW to 34.4 MW

The basis of the costs are model plant data contained in the Alternative Control Techniques (ACT) document (EPA, 1993). Capital and annual cost information was obtained from control-specific cost data based on tons of glass produced. O&M costs were back calculated from annual costs. From these determinations, default cost per ton values were assigned along with a capital to annual cost ratio of 3.7 (Pechan, 1998). A discount rate of 10 percent and a capacity factor of 65 percent are assumed, along with an equipment lifetime of 15 years (EPA, 1993).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 76% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown is estimated using the information for an example small turbine in Table 6-5 of the ACT document for stationary gas turbines. The model plant is a 26.8 megawatt MS5001P turbine. Continuous operation 8,000 hours per year is used to estimate operating costs.

Electricity cost: 0.06 \$/kW-hr

Natural gas cost: \$4.13/MMBtu

Cost Effectiveness: The default cost effectiveness value is \$1,040 per ton NOx reduced from both

AT-A-GLANCE TABLE FOR POINT SOURCES

uncontrolled and RACT baselines (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

Steam is injected into the gas turbine, reducing the temperatures in the NO_x-forming regions. The steam can be injected into the fuel, the combustion air or directly into the combustion chamber (ERG, 2000).

References:

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Stationary Gas Turbines," EPA,-453/R-93-007, Research Triangle Park, NC, January 1993.

ERG, 2000: Eastern Research Group, Inc., "How to Incorporate the Effects of Air Pollution Control Device Efficiencies and Malfunctions into Emission Inventory Estimates," prepared for Emission Inventory Improvement Program, Point Sources Committee, July 2000.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Combustion Turbines - Natural Gas - Small Sources

Control Measure Name: Dry Low NOx Combustors

Rule Name: Not Applicable

Pechan Measure Code: N0243S

POD: 24

Application: This control is the use of low NOx burner (LNB) technology to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another.

This control applies to small (3.3 MW to 34.4 MW) natural gas fired turbines with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

20200201 Natural Gas, Turbine
20200203 Natural Gas, Turbine: Cogeneration
20300202 Natural Gas, Turbine
20300203 Natural Gas, Turbine: Cogeneration

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√/*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 84% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by the following (Pechan, 1998).

Small source = 3.3 MW to 34.4 MW

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). Capital and annual cost information was obtained from the Alternative Control Techniques Document (EPA, 1993). From this analysis, default cost per ton values are assigned along with a capital to annual costs ratio of 9.1. A discount rate of 10 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 15 years (EPA, 1993).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 76% (Pechan, 2001).

O&M Cost Components: There are no O&M costs associated with dry low NOx combustors.

Cost Effectiveness: The default cost effectiveness values are \$490 per ton NOx reduced from uncontrolled and \$540 per ton NOx reduced from RACT (1990\$).

Comments:

AT-A-GLANCE TABLE FOR POINT SOURCES

Status: Demonstrated	Last Reviewed: 2001
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Additional Information:

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNBs create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNBs create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

References:

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Stationary Gas Turbines," EPA-453/R-93-007, Research Triangle Park, NC, January 1993.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Combustion Turbines - Natural Gas - Small Sources

Control Measure Name: Selective Catalytic Reduction (SCR) + Low NOx Burner (LNB)

Rule Name: Not Applicable

Pechan Measure Code: N0244S, N02404

POD: 24

Application: This control is the selective catalytic reduction of NOx through add-on controls. SCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NOx) into molecular nitrogen (N₂) and water vapor (H₂O). The SCR utilizes a catalyst to increase the NOx removal efficiency, which allows the process to occur at lower temperatures.

This control applies to small (<1 ton NOx per OSD) natural gas fired turbines with NOx emissions greater than 10 tons per year.

Affected SCC:

20200201 Natural Gas, Turbine
20200203 Natural Gas, Turbine: Cogeneration
20300202 Natural Gas, Turbine
20300203 Natural Gas, Turbine: Cogeneration

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 94% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NOx emission levels (Pechan, 1998).

Small source = emission levels less than 1 ton per ozone season day

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 15 years (EPA, 1993).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 76% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown is estimated using the information for an example small turbine in Table 6-10 of the ACT document for stationary gas turbines. The model plant is a 26.8 megawatt MS5001P turbine. Continuous operation 8,000 hours per year is used to estimate operating costs.

Electricity cost: 0.06 \$/kW-hr

Natural gas cost: \$4.13/MMBtu

AT-A-GLANCE TABLE FOR POINT SOURCES

Cost Effectiveness: The cost effectiveness values used in AirControlNET are \$2,570 per ton NOx reduced from uncontrolled and \$19,120 per ton NOx reduced from RACT baseline (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

Selective Catalytic Reduction (SCR) has been widely applied to stationary source, fossil fuel-fired, combustion units for emission control since the early 1970s. SCR is typically implemented on units requiring a higher level of NOx control than achievable by SNCR or other combustion controls (EPA, 2002).

Like SNCR, SCR is based on the chemical reduction of the NOx molecule. The primary difference between SNCR and SCR is that SCR uses a metal-based catalyst to increase the rate of reaction (EPA, 2002). A nitrogen based reducing reagent, such as ammonia or urea, is injected into the flue gas. The reagent reacts selectively with the flue gas NOx within a specific temperature range and in the presence of the catalyst and oxygen to reduce the NOx.

The use of a catalyst results in two advantages of the SCR process over SNCR, the higher NOx reduction efficiency and the lower and broader temperature ranges. However, the decrease in reaction temperature and increase in efficiency is accompanied by a significant increase in capital and operating costs (EPA, 2002). The cost increase is due to the large amount of catalyst required.

The SCR system can utilize either aqueous or anhydrous ammonia as the reagent. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Today, catalyst formulations include single component, multi-component, or active phase with a support structure. Most catalyst formulations contain additional compounds or supports, providing thermal and structural stability or to increase surface area (EPA, 2002).

The rate of reaction determines the amount of NOx removed from the flue gas. The important design and operational factors that affect the rate of reduction include: reaction temperature range; residence time available in the optimum temperature range; degree of mixing between the injected reagent and the combustion gases; uncontrolled NOx concentration level; molar ratio of injected reagent to uncontrolled NOx; ammonia slip; catalyst activity; catalyst selectivity; pressure drop across the catalyst; catalyst pitch; catalyst deactivation; and catalyst management (EPA, 2001).

References:

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Stationary Gas Turbines," EPA-453/R-93-007, Research Triangle Park, NC, January 1993.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air

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Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Combustion Turbines - Natural Gas - Small Sources

Control Measure Name: Selective Catalytic Reduction (SCR) + Steam Injection

Rule Name: Not Applicable

Pechan Measure Code: N0245S, N02405

POD: 24

Application: This control is the selective catalytic reduction of NOx through add-on controls. SCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NOx) into molecular nitrogen (N₂) and water vapor (H₂O). The SCR utilizes a catalyst to increase the NOx removal efficiency, which allows the process to occur at lower temperatures.

This control applies to small (<1 ton NOx per OSD) natural gas fired turbines with NOx emissions greater than 10 tons per year.

Affected SCC:

20200201 Natural Gas, Turbine
20200203 Natural Gas, Turbine: Cogeneration
20300202 Natural Gas, Turbine
20300203 Natural Gas, Turbine: Cogeneration

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 95% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NOx emission levels (Pechan, 1998).

Small source = emission levels less than 1 ton per ozone season day

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 15 years (EPA, 1993).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 76% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown is estimated using the information for an example small turbine in Table 6-9 of the ACT document for stationary gas turbines. The model plant is a 26.8 megawatt MS5001P turbine. Continuous operation 8,000 hours per year is used to estimate operating costs.

Electricity cost: 0.06 \$/kW-hr

Natural gas cost: \$4.13/MMBtu

AT-A-GLANCE TABLE FOR POINT SOURCES

Cost Effectiveness: The cost effectiveness values used in AirControlNET are \$2,010 per ton NO_x reduced from uncontrolled and \$8,960 per ton NO_x reduced from RACT baseline (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

Selective Catalytic Reduction (SCR) has been widely applied to stationary source, fossil fuel-fired, combustion units for emission control since the early 1970s. SCR is typically implemented on units requiring a higher level of NO_x control than achievable by SNCR or other combustion controls (EPA, 2002).

Like SNCR, SCR is based on the chemical reduction of the NO_x molecule. The primary difference between SNCR and SCR is that SCR uses a metal-based catalyst to increase the rate of reaction (EPA, 2002). A nitrogen based reducing reagent, such as ammonia or urea, is injected into the flue gas. The reagent reacts selectively with the flue gas NO_x within a specific temperature range and in the presence of the catalyst and oxygen to reduce the NO_x.

The use of a catalyst results in two advantages of the SCR process over SNCR, the higher NO_x reduction efficiency and the lower and broader temperature ranges. However, the decrease in reaction temperature and increase in efficiency is accompanied by a significant increase in capital and operating costs (EPA, 2002). The cost increase is due to the large amount of catalyst required.

The SCR system can utilize either aqueous or anhydrous ammonia as the reagent. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Today, catalyst formulations include single component, multi-component, or active phase with a support structure. Most catalyst formulations contain additional compounds or supports, providing thermal and structural stability or to increase surface area (EPA, 2002).

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include: reaction temperature range; residence time available in the optimum temperature range; degree of mixing between the injected reagent and the combustion gases; uncontrolled NO_x concentration level; molar ratio of injected reagent to uncontrolled NO_x; ammonia slip; catalyst activity; catalyst selectivity; pressure drop across the catalyst; catalyst pitch; catalyst deactivation; and catalyst management (EPA, 2001).

References:

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Stationary Gas Turbines," EPA-453/R-93-007, Research Triangle Park, NC, January 1993.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air

AT-A-GLANCE TABLE FOR POINT SOURCES

Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Combustion Turbines - Natural Gas - Small Sources

Control Measure Name: Selective Catalytic Reduction (SCR) + Water Injection

Rule Name: Not Applicable

Pechan Measure Code: N0246S, N02406

POD: 24

Application: This control is the selective catalytic reduction of NO_x through add-on controls in combination with water injection. SCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NO_x) into molecular nitrogen (N₂) and water vapor (H₂O). The SCR utilizes a catalyst to increase the NO_x removal efficiency, which allows the process to occur at lower temperatures.

This control applies to small (3.3 MW to 34.4MW) natural gas-fired gas turbines with uncontrolled NO_x emissions greater than 10 tons per year.

Affected SCC:

20200201 Natural Gas, Turbine
20200203 Natural Gas, Turbine: Cogeneration
20300202 Natural Gas, Turbine
20300203 Natural Gas, Turbine: Cogeneration

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 95% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by the following (Pechan, 1998).

Small source = 3.3 MW to 34.4 MW

The basis of the costs are model plant data contained in the Alternative Control Techniques (ACT) document (EPA, 1993). Capital and annual cost information was obtained from control-specific cost data based on tons of glass produced. O&M costs were back calculated from annual costs. From these determinations, default cost per ton values were assigned along with a capital to annual cost ratio of 2.8 (Pechan, 1998). A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment lifetime of 15 years (EPA, 1993).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 76% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown is estimated using the information for an example small turbine in Table 6-9 of the ACT document for stationary gas turbines. The model plant is a 26.8 megawatt MS5001P turbine. Continuous operation 8,000 hours per year is used to estimate operating costs.

AT-A-GLANCE TABLE FOR POINT SOURCES

Electricity cost: 0.06 \$/kW-hr
Natural gas cost: \$4.13/MMBtu

Cost Effectiveness: The default cost effectiveness value is \$2,730 per ton NO_x reduced from both uncontrolled and RACT baselines (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

Selective Catalytic Reduction (SCR) has been widely applied to stationary source, fossil fuel-fired, combustion units for emission control since the early 1970s. SCR is typically implemented on units requiring a higher level of NO_x control than achievable by SNCR or other combustion controls (EPA, 2002).

Like SNCR, SCR is based on the chemical reduction of the NO_x molecule. The primary difference between SNCR and SCR is that SCR uses a metal-based catalyst to increase the rate of reaction (EPA, 2002). A nitrogen based reducing reagent, such as ammonia or urea, is injected into the flue gas. The reagent reacts selectively with the flue gas NO_x within a specific temperature range and in the presence of the catalyst and oxygen to reduce the NO_x.

The use of a catalyst results in two advantages of the SCR process over SNCR, the higher NO_x reduction efficiency and the lower and broader temperature ranges. However, the decrease in reaction temperature and increase in efficiency is accompanied by a significant increase in capital and operating costs (EPA, 2002). The cost increase is due to the large amount of catalyst required.

The SCR system can utilize either aqueous or anhydrous ammonia as the reagent. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Today, catalyst formulations include single component, multi-component, or active phase with a support structure. Most catalyst formulations contain additional compounds or supports, providing thermal and structural stability or to increase surface area (EPA, 2002).

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include: reaction temperature range; residence time available in the optimum temperature range; degree of mixing between the injected reagent and the combustion gases; uncontrolled NO_x concentration level; molar ratio of injected reagent to uncontrolled NO_x; ammonia slip; catalyst activity; catalyst selectivity; pressure drop across the catalyst; catalyst pitch; catalyst deactivation; and catalyst management (EPA, 2001).

References:

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Stationary Gas Turbines," EPA-453/R-93-007, Research Triangle Park, NC, January 1993.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

AT-A-GLANCE TABLE FOR POINT SOURCES

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Combustion Turbines - Oil - Small Sources

Control Measure Name: Water Injection

Rule Name: Not Applicable

Pechan Measure Code: N0231S, N02301

POD: 23

Application: This control is the use of water injection to reduce NOx emissions.

This control applies to small (3.3 MW to 34.4MW) oil-fired turbines with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

20200101 Distillate Oil (Diesel), Turbine

20200103 Distillate Oil (Diesel), Turbine: Cogeneration

20300102 Commercial/Institutional, Distillate Oil (Diesel), Turbine

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 68% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by the following (Pechan, 1998).

Small source = 3.3 MW to 34.4 MW

The basis of the costs are model plant data contained in the Alternative Control Techniques (ACT) document (EPA, 1993). Capital and annual cost information was obtained from control-specific cost data based on tons of glass produced. O&M costs were back calculated from annual costs. From these determinations, default cost per ton values were assigned along with a capital to annual cost ratio of 2.9 (Pechan, 1998). A discount rate of 10 percent and a capacity factor of 65 percent are assumed, along with an equipment lifetime of 15 years (EPA, 1993).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 70% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown is estimated using the information for an example small turbine in Table 6-5 of the ACT document for stationary gas turbines. The model plant is a 26.8 megawatt MS5001P turbine. Continuous operation 8,000 hours per year is used to estimate operating costs.

Electricity cost: 0.06 \$/kW-hr

Natural gas cost: \$4.13/MMBtu

Cost Effectiveness: The default cost effectiveness value is \$1,290 per ton NOx reduced from both uncontrolled and RACT baselines (1990\$).

AT-A-GLANCE TABLE FOR POINT SOURCES

Comments:

Status: Demonstrated**Last Reviewed:** 2001

Additional Information:

Water is injected into the gas turbine, reducing the temperatures in the NO_x-forming regions. The water can be injected into the fuel, the combustion air or directly into the combustion chamber (ERG, 2000).

References:

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Stationary Gas Turbines," EPA,-453/R-93-007, Research Triangle Park, NC, January 1993.

ERG, 2000: Eastern Research Group, Inc., "How to Incorporate the Effects of Air Pollution Control Device Efficiencies and Malfunctions into Emission Inventory Estimates," prepared for Emission Inventory Improvement Program, Point Sources Committee, July 2000.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Combustion Turbines - Oil - Small Sources

Control Measure Name: Selective Catalytic Reduction (SCR) + Water Injection

Rule Name: Not Applicable

Pechan Measure Code: N0232S, N02302

POD: 23

Application: This control is the selective catalytic reduction of NO_x through add-on controls in combination with water injection. SCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NO_x) into molecular nitrogen (N₂) and water vapor (H₂O). The SCR utilizes a catalyst to increase the NO_x removal efficiency, which allows the process to occur at lower temperatures.

This control applies to small (3.3 MW to 34.4MW) oil-fired turbines with uncontrolled NO_x emissions greater than 10 tons per year.

Affected SCC:

20200101 Distillate Oil (Diesel), Turbine

20200103 Distillate Oil (Diesel), Turbine: Cogeneration

20300102 Commercial/Institutional, Distillate Oil (Diesel), Turbine

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√/*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 90% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by the following (Pechan, 1998).

Small source = 3.3 MW to 34.4 MW

The basis of the costs are model plant data contained in the Alternative Control Techniques (ACT) document (EPA, 1993). Capital and annual cost information was obtained from control-specific cost data based on tons of glass produced. O&M costs were back calculated from annual costs. From these determinations, default cost per ton values were assigned along with a capital to annual cost ratio of 2.9 (Pechan, 1998). A discount rate of 10 percent and a capacity factor of 65 percent are assumed, along with an equipment lifetime of 15 years (EPA, 1993).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 70% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown is estimated using the information for an example small turbine in Table 6-9 of the ACT document for stationary gas turbines. The model plant is a 26.8 megawatt MS5001P turbine. Continuous operation 8,000 hours per year is used to estimate operating costs.

Electricity cost: 0.06 \$/kW-hr

AT-A-GLANCE TABLE FOR POINT SOURCES

Natural gas cost: \$4.13/MMBtu

Cost Effectiveness: The default cost effectiveness value is \$2,300 per ton NO_x reduced from both uncontrolled and RACT baselines (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

Selective Catalytic Reduction (SCR) has been widely applied to stationary source, fossil fuel-fired, combustion units for emission control since the early 1970s. SCR is typically implemented on units requiring a higher level of NO_x control than achievable by SNCR or other combustion controls (EPA, 2002).

Like SNCR, SCR is based on the chemical reduction of the NO_x molecule. The primary difference between SNCR and SCR is that SCR uses a metal-based catalyst to increase the rate of reaction (EPA, 2002). A nitrogen based reducing reagent, such as ammonia or urea, is injected into the flue gas. The reagent reacts selectively with the flue gas NO_x within a specific temperature range and in the presence of the catalyst and oxygen to reduce the NO_x.

The use of a catalyst results in two advantages of the SCR process over SNCR, the higher NO_x reduction efficiency and the lower and broader temperature ranges. However, the decrease in reaction temperature and increase in efficiency is accompanied by a significant increase in capital and operating costs (EPA, 2002). The cost increase is due to the large amount of catalyst required.

The SCR system can utilize either aqueous or anhydrous ammonia as the reagent. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Today, catalyst formulations include single component, multi-component, or active phase with a support structure. Most catalyst formulations contain additional compounds or supports, providing thermal and structural stability or to increase surface area (EPA, 2002).

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include: reaction temperature range; residence time available in the optimum temperature range; degree of mixing between the injected reagent and the combustion gases; uncontrolled NO_x concentration level; molar ratio of injected reagent to uncontrolled NO_x; ammonia slip; catalyst activity; catalyst selectivity; pressure drop across the catalyst; catalyst pitch; catalyst deactivation; and catalyst management (EPA, 2001).

References:

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Stationary Gas Turbines," EPA-453/R-93-007, Research Triangle Park, NC, January 1993.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity

AT-A-GLANCE TABLE FOR POINT SOURCES

Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Commercial/Institutional - Natural Gas

Control Measure Name: Water Heater Replacement

Rule Name: Not Applicable

Pechan Measure Code: N10601

POD: 106

Application: This control would replace existing water heaters with new water heaters. New water heaters would be required to emit less than or equal to 40 ng NOx per Joule heat output.

This control applies to all natural gas burning water heaters classified under SCC 2103006000.

Affected SCC:

2103006000 Natural Gas, Total: Boilers and IC Engines

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 7% from uncontrolled

Equipment Life: 13 years

Rule Effectiveness: 100%

Penetration: 23%

Cost Basis: In 1994, EPA conducted an analysis of the emission reductions and costs for a Federal Implementation Plan residential water heater rule for the Sacramento, California ozone nonattainment area (EPA, 1995). This analysis found that a rule based on an emission limit of 40 nanograms per joule (ng/j) of heat output for natural gas heaters with a heat input rating less than 75,000 Btu/hr would not result in an increase in the cost of natural gas water heaters. The cost-effectiveness of NOx reductions resulting from low-NOx residential water heaters is, therefore, zero dollar-per-ton of NOx removed. It is assumed that the technology for residential water and space heaters can be transferred to commercial installation at a similar cost to achieve the same percentage reduction (Pechan, 1997).

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$0 per ton NOx reduced (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 1997

Additional Information:

EPA (1995) noted a life expectancy of both conventional and low-NOx units ranging from 10 to 15 years. Thus, rule penetration is based on an average water heater equipment life of 13 years (Pechan, 1996).

AT-A-GLANCE TABLE FOR AREA SOURCES

References:

EPA, 1995: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Costs for the California Federal Implementation Plans for Attainment of the Ozone National Ambient Air Quality Standard," Final Draft, February 1995.

Pechan, 1996: E.H. Pechan & Associates, "The Emission Reduction and Cost Analysis Model for NO_x (ECRAM-NO_x)," Revised Documentation, prepared for U.S. Environmental Protection Agency, Ozone Policy and Strategies Group, Research Triangle Park, NC, September 1996.

Pechan, 1997: E.H. Pechan & Associates, "Additional Control Measure Evaluation for the Integrated Implementation of the Ozone and Particulate Matter National Ambient Air Quality Standards, and Regional Haze Program," prepared for U.S. Environmental Protection Agency, July 1997.

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Commercial/Institutional - Natural Gas

Control Measure Name: Water Heaters + LNB Space Heaters

Rule Name: South Coast and Bay Area AQMD Limits

Pechan Measure Code: N10603

POD: 106

Application: The South Coast and Bay Area AQMDs set emission limits for water heaters and space heaters. This control is based on the installation of low-NOx space heaters and water heaters in commercial and institutional sources for the reduction of NOx emissions.

The control applies to natural gas burning sources classified under SCC 2103006000.

Affected SCC:

2103006000 Natural Gas, Total: Boilers and IC Engines

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 7% from uncontrolled

Equipment Life: 20 years (space heaters)

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The 1997 South Coast AQMP estimates a cost savings for new commercial and residential water heaters meeting a low-NOx standard. The cost savings is based on capital costs associated with installation of energy efficient equipment existing demand-side management programs, energy savings, associated emission reductions, and the prevailing emission credit price (SCAQMD, 1996).

Costs for the space heaters are based on the low-NOx limits established for the South Coast and Bay Area Air Quality Management Districts for space heaters of 0.009 lbs NOx per million Btu. The cost effectiveness estimate for the low-NOx space heater regulation is \$1,600 per ton NOx (STAPPA/ALAPCO, 1994). For this analysis a 75% reduction in commercial space heater NOx emissions is assumed, based on a 20-year equipment life (Pechan, 1997).

The water heater savings and LNB space heater costs are combined to achieve an overall cost effectiveness of \$1,230 per ton NOx reduced.

Cost Effectiveness: The cost effectiveness is \$1,230 per ton NOx reduced (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 1997

Additional Information:

AT-A-GLANCE TABLE FOR AREA SOURCES

References:

Pechan, 1997: E.H. Pechan & Associates, Inc., "Additional Control Measure Evaluation for the Integrated Implementation of the Ozone and Particulate Matter National Ambient Air Quality Standards, and Regional Haze Program," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, July 1997.

SCAQMD, 1996: South Coast Air Quality Management District, "1997 Air Quality Management Plan, Appendix IV-A: Stationary and Mobile Source Control Measures," August 1996.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Commercial/Institutional Incinerators

Control Measure Name: Selective Non-Catalytic Reduction (SNCR)

Rule Name: Not Applicable

Pechan Measure Code: N0591S, N05901

POD: 59

Application: This control is the reduction of NO_x emission through selective non-catalytic reduction add-on controls. SNCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NO_x) into molecular nitrogen (N₂) and water vapor (H₂O).

This control applies to commercial/institutional incinerators with uncontrolled NO_x emissions greater than 10 tons per year.

Affected SCC:

50200101 Solid Waste Disposal - Commercial/Institutional, Incineration, Multiple Chamber
50200102 Solid Waste Disposal - Commercial/Institutional, Incineration, Single Chamber
50200103 Solid Waste Disposal - Commercial/Institutional, Incineration, Controlled Air
50200506 Solid Waste Disposal - Commercial/Institutional, Incineration: Special Purpose, Sludge

Pollutant(s)	PM10	PM2.5	EC	OC	NO _x	VOC	SO ₂	NH ₃	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 45% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NO_x emission levels (Pechan, 1998).

Small source = emission levels less than 1 ton per ozone season day

Large source = emission levels greater than 1 ton per ozone season day

Costs for stationary source NO_x control are based on an analysis of EPA's NO_x State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 20 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than 70% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown is estimated using the information in Chapter and Appendix A of the MWC ACT document. The cost outputs for conventional SNCR applied to the 400 ton per day model combustor (Table 3-3) are used to estimate the O&M cost breakdown. The tipping fee (\$1.47 per ton) is included as a waste disposal cost (direct annual cost).

Electricity Cost: 0.046 \$/kW-hr

AT-A-GLANCE TABLE FOR POINT SOURCES

Cost Effectiveness: The cost effectiveness (for both small and large sources) used in AirControlNET for both reductions from baseline and reductions from RACT is \$1,130 per ton NO_x reduced (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

SNCR is the reduction of NO_x in flue gas to N₂ and water vapor. This reduction is done with a nitrogen based reducing reagent, such as ammonia or urea. The reagent can react with a number of flue gas components. However, the NO_x reduction reaction is favored for a specific temperature range and in the presence of oxygen (EPA, 2002).

Both ammonia and urea are used as reagents. The cost of the reagent represents a large part of the annual costs of an SNCR system. Ammonia is generally less expensive than urea. However, the choice of reagent is also based on physical properties and operational considerations (EPA, 2002).

Ammonia can be utilized in either aqueous or anhydrous form. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Urea based systems have several advantages, including several safety aspects. Urea is a nontoxic, less volatile liquid that can be stored and handled more safely than ammonia. Urea solution droplets can penetrate farther into the flue gas when injected into the boiler, enhancing mixing (EPA, 2002). Because of these advantages, urea is more commonly used than ammonia in large boiler applications.

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include:

Reaction temperature range;
Residence time available in the optimum temperature range;
Degree of mixing between the injected reagent and the combustion gases
Uncontrolled NO_x concentration level;
Molar ratio of injected reagent to uncontrolled NO_x ; and
Ammonia slip.

References:

EPA, 1994: U.S. Environmental Protection Agency, Radian Corporation, "Alternative Control Techniques Document-- NO_x Emissions from Municipal Waste Combustion," EPA-600/R-94-208, Research Triangle Park, NC, December 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

AT-A-GLANCE TABLE FOR POINT SOURCES

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Conv Coating of Prod; Acid Cleaning Bath - Small Sources

Control Measure Name: Low NOx Burner

Rule Name: Not Applicable

Pechan Measure Code: N0791S, N07901

POD: 79

Application: This control is the use of low NOx burner (LNB) technology to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another.

This control is applicable to small (<1 ton NOx per OSD) acid cleaning bath/conversion coating processes at metal product fabricating operations with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

30901102 Fabricated Metal Products, Conversion Coating, Acid Cleaning Bath (Pickling)

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 50% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NOx emission levels (Pechan, 1998).

Small source = emissions level less than 1 ton per ozone season day

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). Capital and annual cost information was obtained from the Alternative Control Techniques Document (EPA, 1993). The data provided for LNB applied to process heaters firing natural gas are assumed to be representative of the costs and emission reductions for this source. From this analysis, default cost per ton values are assigned along with a capital to annual costs ratio of 7.3. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 15 years (EPA, 1993).

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$2,200 per ton NOx reduced from both uncontrolled and RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 1998

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

The source of emissions for acid cleaning baths come from heating of the baths.

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNBs create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNBs create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

References:

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Process Heaters," EPA-453/R-93-034, Research Triangle Park, NC, September, 1993.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Diesel Locomotives

Control Measure Name: Selective Catalytic Reduction (SCR)

Rule Name: Not Applicable

Pechan Measure Code: N13701

POD: 137

Application: This control is the selective catalytic reduction of Nox through add-on controls. SCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (Nox) into molecular nitrogen (N₂) and water vapor (H₂O). The SCR utilizes a catalyst to increase the Nox removal efficiency, which allows the process to occur at lower temperatures.

Applies to line and yard diesel locomotive engines

Affected SCC:

2285002006 - Railroad Equipment, Diesel, Line Haul Locomotives: Class I Operations
2285002007 - Railroad Equipment, Diesel, Line Haul Locomotives: Class II / III Operations
2285002008 - Railroad Equipment, Diesel, Line Haul Locomotives: Passenger Trains (Amtrak)
2285002009 - Railroad Equipment, Diesel, Line Haul Locomotives: Commuter Lines
2285002010 - Railroad Equipment, Diesel, Yard Locomotives

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 72% from uncontrolled (CARB, 1995)

Equipment Life: NA

Rule Effectiveness: NA

Penetration: NA

Cost Basis: A 1995 report prepared for the California Resources Board (CARB) contains information for retrofit emission control techniques available for line-haul, local, and yard locomotives. These retrofit controls include Selective Catalytic Reduction and conversion to dual fuel (including liquified natural gas) capability (EFEE, 1995). Pechan developed ControlNET inputs for these controls using the reported emission reduction percentages and cost-effectiveness values developed for CARB.

Cost Effectiveness: The cost effectiveness is \$1,400 per ton of Nox reduction (1995\$).

Comments:

Status: Demonstrated

Last Reviewed: 2004

Additional Information:

References:

EFEE, 1995. Engine, Fuel, and Emissions Engineering, Inc., "Controlling Locomotive Emissions in California, Technology, Cost-Effectiveness, and Regulatory Strategy," Final report prepared for the California Air Resources Board, Sacramento, CA. March 1995.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Fiberglass Manufacture; Textile-Type; Recuperative Furnaces

Control Measure Name: Low NOx Burner

Rule Name: Not Applicable

Pechan Measure Code: N0763S, N07603

POD: 76

Application: This control is the use of low NOx burner (LNB) technology to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another.

This control is applicable to textile-type fiberglass manufacturing operations with recuperative furnaces and uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

30501212 Fiberglass Manufacturing, Recuperative Furnace (Textile-type Fiber)

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 40% from uncontrolled

Equipment Life: 3 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). Capital and annual cost information was obtained from the Alternative Control Techniques Document (EPA, 1994). The data provided for LNB applied to process heaters firing natural gas are assumed to be representative of the costs and emission reductions for this source. From this analysis, default cost per ton values are assigned along with a capital to annual costs ratio of 2.2. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 3 years (EPA, 1994).

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$1,690 per ton NOx reduced from both uncontrolled and RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 1998

Additional Information:

Recuperative furnaces may be gas- or oil-fired.

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNBs create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNBs create a lean combustion zone that is relatively cool due to the presence of

AT-A-GLANCE TABLE FOR POINT SOURCES

excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Glass Manufacturing," EPA,-453/R-94-037, Research Triangle Park, NC, June 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Fluid Catalytic Cracking Units - Small Sources

Control Measure Name: Low NOx Burner + Flue Gas Recirculation

Rule Name: Not Applicable

Pechan Measure Code: N0782S, N07802

POD: 78

Application: This control is the use of low NOx burner (LNB) technology and flue gas recirculation (FGR) to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another.

This control is applicable to small (<1 ton per OSD) fluid catalytic cracking units with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

30600201 Petroleum Industry, Catalytic Cracking Units, Fluid Catalytic Cracking Unit

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 55% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by power output (Pechan, 1998).

Small source = less than 1 ton NOx per ozone season day

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). The basis of the costs are model plant data in the Alternative Control Techniques (ACT) document (EPA, 1993). From this analysis, default cost per ton values are assigned along with a capital to annual costs ratio of 6.9. An equipment life of 15 years is assumed (EPA, 1993).

Cost Effectiveness: The default cost effectiveness values are \$3,190 per ton NOx reduced from uncontrolled and \$1,430 per ton NOx reduced from RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

The source of emissions for fluidized catalytic cracking come from process heaters and catalyst regenerators.

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-

AT-A-GLANCE TABLE FOR POINT SOURCES

air LNBs create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNBs create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

References:

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Process Heaters," EPA-453/R-93-034, Research Triangle Park, NC, September 1993.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Fuel Fired Equipment - Process Heaters

Control Measure Name: Low Nox Burner + Flue Gas Recirculation

Rule Name: Not Applicable

Pechan Measure Code: N0692S, N06902

POD: 72

Application: This control is the use of low NOx burner (LNB) technology and flue gas recirculation (FGR) to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another.

This control is applicable to small process heaters with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

30490033 Fuel Fired Equipment, Natural Gas: Furnaces

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 50% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by power output (Pechan, 1998).

Small source = less than 1 ton NOx per ozone season day

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). The basis of the costs are model plant data in the Alternative Control Techniques (ACT) document (EPA, 1993). From this analysis, default cost per ton values are assigned along with a capital to annual costs ratio of 7.0. A discount rate of 10 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 15 years (EPA, 1993).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 50% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown is estimated using the detailed information in Table 6-4 and Ch. 6 of the Process Heaters ACT. The breakdown was obtained using the O&M costs for a mechanical draft process heater fired on distillate oil and having a capacity of 69 MMBTU per hour. The cost percentage is applied to heaters fired on LPG via technology transfer (Pechan, 1998). A capacity factor of 0.58 is used in estimating the O&M cost breakdown.

Electricity: \$0.06 per kw-hr

AT-A-GLANCE TABLE FOR POINT SOURCES

Cost Effectiveness: The default cost effectiveness values are \$570 per ton Nox reduced from uncontrolled.

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNBs create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNBs create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

References:

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Process Heaters," EPA-453/R-93-034, Research Triangle Park, NC, September 1993.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Fuel Fired Equipment; Furnaces; Natural Gas

Control Measure Name: Low NOx Burner

Rule Name: Not Applicable

Pechan Measure Code: N0721L, N0721S, N07201

POD: 72

Application: This control is the use of low NOx burner (LNB) technology to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another.

This control applies to natural gas fired equipment classified under SCC 30490033 with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

30490033 Fuel Fired Equipment, Natural Gas: Furnaces

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 50% from uncontrolled

Equipment Life: 10 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). Capital and annual cost information was obtained from the Alternative Control Techniques Document (EPA, 1993). The data provided for LNB applied to process heaters firing natural gas are assumed to be representative of the costs and emission reductions for this source. From this analysis, default cost per ton values are assigned along with a capital to annual costs ratio of 7.0. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 10 years (EPA, 1993)

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$570 per ton NOx reduced from both uncontrolled and RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 1998

Additional Information:

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNBs create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNBs create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

AT-A-GLANCE TABLE FOR POINT SOURCES

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Iron and Steel Mills," EPA-453/R-94-065, Research Triangle Park, NC, September 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Glass Manufacturing - Containers

Control Measure Name: Electric Boost

Rule Name: Not Applicable

Pechan Measure Code: N0301S, N03001

POD: 30

Application: This control is the use of electric boost technologies to reduce NOx emissions from glass manufacturing operations.

This control applies to container glass manufacturing operations classified under SCC 30501402.

Affected SCC:

30501402 Mineral Products, Glass Manufacture, Container Glass: Melting Furnace

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√/*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 10% from uncontrolled

Equipment Life: 10 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The basis of the costs are model plant data contained in the Alternative Control Techniques (ACT) document (EPA, 1994). Capital, and annual cost information that was obtained from control-specific cost data based on tons of glass produced. O&M costs were back calculated from annual costs. From these determinations, default cost per ton values were assigned along with a capital to annual cost ratio of 4.5. A discount rate of 10 percent and a capacity factor of 65 percent are assumed, along with an equipment lifetime of 10 years (EPA, 1994).

Cost Effectiveness: The default cost effectiveness value used in AirControlNET is \$7,150 per ton NOx reduced from both uncontrolled and RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

The 250 tons per day plant is assumed to be representative of container glass plants (Pechan, 1998).

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Glass Manufacturing," EPA,-453/R-94-037, Research Triangle Park, NC, June 1994.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air

AT-A-GLANCE TABLE FOR POINT SOURCES

Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

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AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Glass Manufacturing - Containers

Control Measure Name: Cullet Preheat

Rule Name: Not Applicable

Pechan Measure Code: N0302S, N03002

POD: 30

Application: This control is the use of cullet preheat technologies to reduce NOx emissions from glass manufacturing operations.

This control is applicable to container glass manufacturing operations classified under 305010402.

Affected SCC:

30501402 Mineral Products, Glass Manufacture, Container Glass: Melting Furnace

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 25% from uncontrolled

Equipment Life: 10 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The basis of the costs are model plant data contained in the Alternative Control Techniques (ACT) document (EPA, 1994). Capital and annual cost information was obtained from control-specific cost data based on tons of glass produced. O&M costs were back calculated from annual costs. From these determinations, default cost per ton values were assigned along with a capital to annual cost ratio of 4.5 (Pechan, 1998). A discount rate of 10 percent and a capacity factor of 65 percent are assumed, along with an equipment lifetime of 10 years (EPA, 1994).

Cost Effectiveness: The default cost effectiveness value used in AirControlNET is \$940 per ton NOx reduced from both uncontrolled and RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 1998

Additional Information:

The 250 tons per day plant is assumed to be representative of container glass plants (Pechan, 1998).

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Glass Manufacturing," EPA,-453/R-94-037, Research Triangle Park, NC, June 1994.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air

AT-A-GLANCE TABLE FOR POINT SOURCES

Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

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AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Glass Manufacturing - Containers

Control Measure Name: Low NOx Burner

Rule Name: Not Applicable

Pechan Measure Code: N0303S, N03003

POD: 30

Application: This control is the use of low NOx burner (LNB) technology to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another.

This control is applicable to container glass manufacturing operations classified under 305010402 with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

30501402 Mineral Products, Glass Manufacture, Container Glass: Melting Furnace

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 40% from uncontrolled

Equipment Life: 10 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The basis of the costs are model plant data contained in the Alternative Control Techniques (ACT) document (EPA, 1994). Capital and annual cost information was obtained from control-specific cost data based on tons of glass produced. O&M costs were back calculated from annual costs. From these determinations, default cost per ton values were assigned along with a capital to annual cost ratio of 2.2 (Pechan, 1998). A discount rate of 10 percent and a capacity factor of 65 percent are assumed, along with an equipment lifetime of 10 years (EPA, 1994).

Cost Effectiveness: The default cost effectiveness value used in AirControlNET is \$1,690 per ton NOx reduced from both uncontrolled and RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 1998

Additional Information:

The 250 tons per day plant is assumed to be representative of container glass plants (Pechan, 1998).

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNBs create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNBs create a lean combustion zone that is relatively cool due to the presence of

AT-A-GLANCE TABLE FOR POINT SOURCES

excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Glass Manufacturing," EPA,-453/R-94-037, Research Triangle Park, NC, June 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 1998.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Glass Manufacturing - Containers

Control Measure Name: Selective Non-Catalytic Reduction (SNCR)

Rule Name: Not Applicable

Pechan Measure Code: N0304S, N03004

POD: 30

Application: This control is the reduction of NO_x emission through selective non-catalytic reduction add-on controls. SNCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NO_x) into molecular nitrogen (N₂) and water vapor (H₂O).

This control applies to glass-container manufacturing operations (SCC 30501402) with uncontrolled NO_x emissions greater than 10 tons per year.

Affected SCC:

30501402 Mineral Products, Glass Manufacture, Container Glass: Melting Furnace

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 40% from uncontrolled

Equipment Life: 10 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NO_x emission levels (Pechan, 1998).

Small source = emission levels less than 1 ton per ozone season day

Large source = emission levels greater than 1 ton per ozone season day

Costs for stationary source NO_x control are based on an analysis of EPA's NO_x State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 10 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than 70% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown is estimated by applying percentages of O&M breakdown for SNCR as applied to process heaters, using detailed information found in Table 6-3 and Chapter 6 of the Process Heater ACT document. The breakdown was obtained using the O&M costs for a 250 ton per day furnace.

Electricity: \$0.06 per kw-hr

Fuel (nat gas): \$2.00 per MMBTU

Ammonia: \$0.125 per lb

AT-A-GLANCE TABLE FOR POINT SOURCES

Cost Effectiveness: The cost effectiveness (for both small and large sources) used in AirControlNET for both reductions from baseline and reductions from RACT is \$1,770 per ton NO_x reduced (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

SNCR is the reduction of NO_x in flue gas to N₂ and water vapor. This reduction is done with a nitrogen based reducing reagent, such as ammonia or urea. The reagent can react with a number of flue gas components. However, the NO_x reduction reaction is favored for a specific temperature range and in the presence of oxygen (EPA, 2002).

Both ammonia and urea are used as reagents. The cost of the reagent represents a large part of the annual costs of an SNCR system. Ammonia is generally less expensive than urea. However, the choice of reagent is also based on physical properties and operational considerations (EPA, 2002).

Ammonia can be utilized in either aqueous or anhydrous form. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Urea based systems have several advantages, including several safety aspects. Urea is a nontoxic, less volatile liquid that can be stored and handled more safely than ammonia. Urea solution droplets can penetrate farther into the flue gas when injected into the boiler, enhancing mixing (EPA, 2002). Because of these advantages, urea is more commonly used than ammonia in large boiler applications.

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include:

Reaction temperature range;

Residence time available in the optimum temperature range;

Degree of mixing between the injected reagent and the combustion gases

Uncontrolled NO_x concentration level;

Molar ratio of injected reagent to uncontrolled NO_x ; and ammonia slip.

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Glass Manufacturing," EPA,-453/R-94-037, Research Triangle Park, NC, June 1994.

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Process Heaters," EPA,-453/R-93-034, Research Triangle Park, NC, September 1993.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air

AT-A-GLANCE TABLE FOR POINT SOURCES

Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Glass Manufacturing - Containers

Control Measure Name: Selective Catalytic Reduction (SCR)

Rule Name: Not Applicable

Pechan Measure Code: N0305S, N03005

POD: 30

Application: This control is the selective catalytic reduction of NOx through add-on controls. SCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NOx) into molecular nitrogen (N₂) and water vapor (H₂O). The SCR utilizes a catalyst to increase the NOx removal efficiency, which allows the process to occur at lower temperatures.

Applies to glass-container manufacturing processes, classified under SCC 30501402 and uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

30501402 Mineral Products, Glass Manufacture, Container Glass: Melting Furnace

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 75% from uncontrolled

Equipment Life: 10 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NOx emission levels (Pechan, 1998).

Small source = emission levels less than 1 ton per ozone season day

Large source = emission levels greater than 1 ton per ozone season day

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 10 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than 70% (Pechan, 2001).

Cost Effectiveness: The cost effectiveness values (for both small and large sources) used in AirControlNET are \$2,200 per ton NOx reduced from both uncontrolled and RACT baselines (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

Selective Catalytic Reduction (SCR) has been widely applied to stationary source, fossil fuel-fired, combustion units for emission control since the early 1970s. SCR is typically implemented on units requiring a higher level of NO_x control than achievable by SNCR or other combustion controls (EPA, 2002).

Like SNCR, SCR is based on the chemical reduction of the NO_x molecule. The primary difference between SNCR and SCR is that SCR uses a metal-based catalyst to increase the rate of reaction (EPA, 2002). A nitrogen based reducing reagent, such as ammonia or urea, is injected into the flue gas. The reagent reacts selectively with the flue gas NO_x within a specific temperature range and in the presence of the catalyst and oxygen to reduce the NO_x.

The use of a catalyst results in two advantages of the SCR process over SNCR, the higher NO_x reduction efficiency and the lower and broader temperature ranges. However, the decrease in reaction temperature and increase in efficiency is accompanied by a significant increase in capital and operating costs (EPA, 2002). The cost increase is due to the large amount of catalyst required.

The SCR system can utilize either aqueous or anhydrous ammonia as the reagent. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Today, catalyst formulations include single component, multi-component, or active phase with a support structure. Most catalyst formulations contain additional compounds or supports, providing thermal and structural stability or to increase surface area (EPA, 2002).

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include: reaction temperature range; residence time available in the optimum temperature range; degree of mixing between the injected reagent and the combustion gases; uncontrolled NO_x concentration level; molar ratio of injected reagent to uncontrolled NO_x; ammonia slip; catalyst activity; catalyst selectivity; pressure drop across the catalyst; catalyst pitch; catalyst deactivation; and catalyst management (EPA, 2001).

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Glass Manufacturing," EPA-453/R-94-037, Research Triangle Park, NC, June 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Glass Manufacturing - Containers

Control Measure Name: OXY-Firing

Rule Name: Not Applicable

Pechan Measure Code: N0306S, N03006

POD: 30

Application: This control is the use of OXY-firing to reduce NOx emissions.

This control applies to container-glass manufacturing operations with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

30501402 Mineral Products, Glass Manufacture, Container Glass: Melting Furnace

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√/*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 85% from uncontrolled

Equipment Life: 10 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Cost equations for glass manufacturing NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan-Avanti, 1998). The basis of the costs are model plant data contained in the Alternative Control Techniques (ACT) document. The 50 tons per day plant was assumed to be representative of pressed glass plants, the 250 tons per day plant was assumed to be representative of container glass plants, and the 500 tons per day plant was assumed to be representative of flat glass plants. Capital, and annual cost information that was obtained from control-specific cost data based on tons of glass produced. O&M costs were back calculated from annual costs. From these determinations, default cost per ton values were assigned. A capital cost to annual cost ratio was developed to estimate default capital and O&M costs. A discount rate of 10% was assumed for all sources. The equipment life of varied from 3 to 10 years by control.

Cost Effectiveness: The default cost effectiveness value is \$4,590 per ton NOx reduced from both uncontrolled and RACT baselines (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

The 550 tons per day plant is assumed to be representative of container glass plants (Pechan, 1998).

AT-A-GLANCE TABLE FOR POINT SOURCES

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Glass Manufacturing," EPA,-453/R-94-037, Research Triangle Park, NC, June 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 1998.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Glass Manufacturing - Flat

Control Measure Name: Electric Boost

Rule Name: Not Applicable

Pechan Measure Code: N0311L, N0311S, N03101

POD: 31

Application: This control is the use of electric boost technologies to reduce NOx emissions from glass manufacturing operations.

This control applies to flat glass manufacturing operations classified under SCC 30501403.

Affected SCC:

30501403 Mineral Products, Glass Manufacture, Flat Glass: Melting Furnace

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 10% from uncontrolled

Equipment Life: 10 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The basis of the costs are model plant data contained in the Alternative Control Techniques (ACT) document (EPA, 1994). Capital and annual cost information that was obtained from control-specific cost data based on tons of glass produced. O&M costs were back calculated from annual costs. From these determinations, default cost per ton values were assigned along with a capital to annual cost ratio of 4.5. A discount rate of 10 percent and a capacity factor of 65 percent are assumed, along with an equipment lifetime of 10 years (EPA, 1994).

Cost Effectiveness: The default cost effectiveness value used in AirControlNET is \$2,320 per ton NOx reduced from both uncontrolled and RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 1998

Additional Information:

The 500 tons per day plant is assumed to be representative of flat glass plants (Pechan, 1998).

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Glass Manufacturing," EPA-453/R-94-037, Research Triangle Park, NC, June 1994.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle

AT-A-GLANCE TABLE FOR POINT SOURCES

Park, NC, September 1998.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Glass Manufacturing - Flat

Control Measure Name: Low NOx Burner

Rule Name: Not Applicable

Pechan Measure Code: N0312S, N0312L, N03102

POD: 31

Application: This control is the use of low NOx burner (LNB) technology to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another.

This control is applicable to flat glass manufacturing operations classified under 305010404 with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

30501403 Mineral Products, Glass Manufacture, Flat Glass: Melting Furnace

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 40% from uncontrolled

Equipment Life: 3 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The basis of the costs are model plant data contained in the Alternative Control Techniques (ACT) document (EPA, 1994). Capital and annual cost information is obtained from control-specific cost data based on tons of glass produced. O&M costs were back calculated from annual costs. From these determinations, default cost per ton values were assigned along with a capital to annual cost ratio of 2.2 (Pechan, 1998). A discount rate of 10 percent and a capacity factor of 65 percent are assumed, along with an equipment lifetime of 3 years (EPA, 1994).

Cost Effectiveness: The default cost effectiveness value used in AirControlNET is \$700 per ton NOx reduced from both uncontrolled and RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 1998

Additional Information:

The 500 tons per day plant is assumed to be representative of flat glass plants (Pechan, 1998).

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNBs create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNBs create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

AT-A-GLANCE TABLE FOR POINT SOURCES

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Glass Manufacturing," EPA,-453/R-94-037, Research Triangle Park, NC, June 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 1998.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Glass Manufacturing - Flat

Control Measure Name: OXY-Firing

Rule Name: Not Applicable

Pechan Measure Code: N0315L, N0315S, N03105

POD: 31

Application: This control is the use of OXY-firing to reduce NOx emissions.

This control applies to flat-glass manufacturing operations with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

30501403 Mineral Products, Glass Manufacture, Flat Glass: Melting Furnace

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 85% from uncontrolled

Equipment Life: 10 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The basis of the costs are model plant data contained in the Alternative Control Techniques (ACT) document (EPA, 1994). Capital and annual cost information is obtained from control-specific cost data based on tons of glass produced. O&M costs were back calculated from annual costs. From these determinations, default cost per ton values were assigned along with a capital to annual cost ratio of 2.7 (Pechan, 1998). A discount rate of 10 percent and a capacity factor of 65 percent are assumed, along with an equipment lifetime of 10 years (EPA, 1994).

Cost Effectiveness: The default cost effectiveness value is \$1,900 per ton NOx reduced from both uncontrolled and RACT baselines (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

The 500 tons per day plant is assumed to be representative of flat glass plants (Pechan, 1998).

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Glass Manufacturing," EPA-453/R-94-037, Research Triangle Park, NC, June 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

AT-A-GLANCE TABLE FOR POINT SOURCES

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 1998.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Glass Manufacturing - Flat - Large Sources

Control Measure Name: Selective Non-Catalytic Reduction (SNCR)

Rule Name: Not Applicable

Pechan Measure Code: N0313L, N03103

POD: 31

Application: This control is the reduction of NO_x emission through selective non-catalytic reduction add-on controls. SNCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NO_x) into molecular nitrogen (N₂) and water vapor (H₂O).

This control applies to large (>1 ton NO_x emissions per OSD) flat-glass manufacturing operations (SCC 30501403) with uncontrolled NO_x emissions greater than 10 tons per year.

Affected SCC:

30501403 Mineral Products, Glass Manufacture, Flat Glass: Melting Furnace

Pollutant(s)	PM10	PM2.5	EC	OC	NO _x	VOC	SO ₂	NH ₃	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 40% from uncontrolled

Equipment Life: 10 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NO_x emission levels (Pechan, 1998).

Large source = emission levels greater than 1 ton per ozone season day

Costs for stationary source NO_x control are based on an analysis of EPA's NO_x State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 10 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than 70% (Pechan, 2001).

Cost Effectiveness: The cost effectiveness used in AirControlNET for both reductions from baseline and reductions from RACT is \$740 per ton NO_x reduced (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

SNCR is the reduction of NO_x in flue gas to N₂ and water vapor. This reduction is done with a nitrogen based reducing reagent, such as ammonia or urea. The reagent can react with a number of flue gas components. However, the NO_x reduction reaction is favored for a specific temperature

AT-A-GLANCE TABLE FOR POINT SOURCES

range and in the presence of oxygen (EPA, 2002).

Both ammonia and urea are used as reagents. The cost of the reagent represents a large part of the annual costs of an SNCR system. Ammonia is generally less expensive than urea. However, the choice of reagent is also based on physical properties and operational considerations (EPA, 2002).

Ammonia can be utilized in either aqueous or anhydrous form. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Urea based systems have several advantages, including several safety aspects. Urea is a nontoxic, less volatile liquid that can be stored and handled more safely than ammonia. Urea solution droplets can penetrate farther into the flue gas when injected into the boiler, enhancing mixing (EPA, 2002). Because of these advantages, urea is more commonly used than ammonia in large boiler applications.

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include:

Reaction temperature range;
Residence time available in the optimum temperature range;
Degree of mixing between the injected reagent and the combustion gases
Uncontrolled NO_x concentration level;
Molar ratio of injected reagent to uncontrolled NO_x ; and
Ammonia slip.

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Glass Manufacturing," EPA-453/R-94-037, Research Triangle Park, NC, June 1994.

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Process Heaters," EPA-453/R-93-034, Research Triangle Park, NC, September 1993.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Glass Manufacturing - Flat - Large Sources

Control Measure Name: Selective Catalytic Reduction (SCR)

Rule Name: Not Applicable

Pechan Measure Code: N0314L, N03104

POD: 31

Application: This control is the selective catalytic reduction of NOx through add-on controls. SCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NOx) into molecular nitrogen (N2) and water vapor (H2O). The SCR utilizes a catalyst to increase the NOx removal efficiency, which allows the process to occur at lower temperatures.

Applies to large(>1 ton NOx per OSD) flat-glass manufacturing operations (SCC 30501403) with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

30501403 Mineral Products, Glass Manufacture, Flat Glass: Melting Furnace

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 75% from uncontrolled

Equipment Life: 10 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NOx emission levels (Pechan, 1998).

Large source = emission levels greater than 1 ton per ozone season day

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 10 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than 70% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown is estimated by applying percentages of O&M breakdown for SCR as applied to process heaters, using detailed information found in Table 6-3 and Chapter 6 of the Process Heater ACT document. The breakdown was obtained using the O&M costs for a 750 ton per day furnace.

Electricity: \$0.06 per kw-hr

Fuel (nat gas): \$2.00 per MMBTU

Ammonia: \$0.125 per lb

AT-A-GLANCE TABLE FOR POINT SOURCES

Cost Effectiveness: The cost effectiveness values used in AirControlNET are \$710 per ton NOx reduced from both uncontrolled and RACT baselines (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

Selective Catalytic Reduction (SCR) has been widely applied to stationary source, fossil fuel-fired, combustion units for emission control since the early 1970s. SCR is typically implemented on units requiring a higher level of NOx control than achievable by SNCR or other combustion controls (EPA, 2002).

Like SNCR, SCR is based on the chemical reduction of the NOx molecule. The primary difference between SNCR and SCR is that SCR uses a metal-based catalyst to increase the rate of reaction (EPA, 2002). A nitrogen based reducing reagent, such as ammonia or urea, is injected into the flue gas. The reagent reacts selectively with the flue gas NOx within a specific temperature range and in the presence of the catalyst and oxygen to reduce the NOx.

The use of a catalyst results in two advantages of the SCR process over SNCR, the higher NOx reduction efficiency and the lower and broader temperature ranges. However, the decrease in reaction temperature and increase in efficiency is accompanied by a significant increase in capital and operating costs (EPA, 2002). The cost increase is due to the large amount of catalyst required.

The SCR system can utilize either aqueous or anhydrous ammonia as the reagent. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Today, catalyst formulations include single component, multi-component, or active phase with a support structure. Most catalyst formulations contain additional compounds or supports, providing thermal and structural stability or to increase surface area (EPA, 2002).

The rate of reaction determines the amount of NOx removed from the flue gas. The important design and operational factors that affect the rate of reduction include: reaction temperature range; residence time available in the optimum temperature range; degree of mixing between the injected reagent and the combustion gases; uncontrolled NOx concentration level; molar ratio of injected reagent to uncontrolled NOx; ammonia slip; catalyst activity; catalyst selectivity; pressure drop across the catalyst; catalyst pitch; catalyst deactivation; and catalyst management (EPA, 2001).

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Glass Manufacturing," EPA-453/R-94-037, Research Triangle Park, NC, June 1994.

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Process Heaters," EPA-453/R-93-034, Research Triangle Park, NC, September 1993.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

AT-A-GLANCE TABLE FOR POINT SOURCES

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Glass Manufacturing - Flat - Small Sources

Control Measure Name: Selective Non-Catalytic Reduction (SNCR)

Rule Name: Not Applicable

Pechan Measure Code: N0313S

POD: 31

Application: This control is the reduction of NO_x emission through selective non-catalytic reduction add-on controls. SNCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NO_x) into molecular nitrogen (N₂) and water vapor (H₂O).

This control applies to small (<1 ton NO_x emissions per OSD) flat-glass manufacturing operations (SCC 30501403) with uncontrolled NO_x emissions greater than 10 tons per year.

Affected SCC:

30501403 Mineral Products, Glass Manufacture, Flat Glass: Melting Furnace

Pollutant(s)	PM10	PM2.5	EC	OC	NO _x	VOC	SO ₂	NH ₃	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 40% from uncontrolled

Equipment Life: 10 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NO_x emission levels (Pechan, 1998).

Small source = emission levels less than 1 ton per ozone season day

Costs for stationary source NO_x control are based on an analysis of EPA's NO_x State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned for small sources. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 10 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than 70% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown is estimated by applying percentages of O&M breakdown for SNCR as applied to process heaters, using detailed information found in Table 6-3 and Chapter 6 of the Process Heater ACT document. The breakdown was obtained using the O&M costs for a 750 ton per day furnace.

Electricity: \$0.06 per kw-hr

Fuel (nat gas): \$2.00 per MMBTU

Ammonia: \$0.125 per lb

AT-A-GLANCE TABLE FOR POINT SOURCES

O&M Cost Components: The O&M cost breakdown is estimated by applying percentages of O&M breakdown for SNCR as applied to process heaters, using detailed information found in Table 6-3 and Chapter 6 of the Process Heater ACT document. The breakdown was obtained using the O&M costs for a 750 ton per day furnace.

Electricity: \$0.06 per kw-hr
Fuel (nat gas): \$2.00 per MMBTU
Ammonia: \$0.125 per lb

Cost Effectiveness: The cost effectiveness used in AirControlNET for both reductions from baseline and reductions from RACT is \$740 per ton NO_x reduced (1990\$).

Comments:

Status: Demonstrated	Last Reviewed: 2001
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Additional Information:

SNCR is the reduction of NO_x in flue gas to N₂ and water vapor. This reduction is done with a nitrogen based reducing reagent, such as ammonia or urea. The reagent can react with a number of flue gas components. However, the NO_x reduction reaction is favored for a specific temperature range and in the presence of oxygen (EPA, 2002).

Both ammonia and urea are used as reagents. The cost of the reagent represents a large part of the annual costs of an SNCR system. Ammonia is generally less expensive than urea. However, the choice of reagent is also based on physical properties and operational considerations (EPA, 2002).

Ammonia can be utilized in either aqueous or anhydrous form. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Urea based systems have several advantages, including several safety aspects. Urea is a nontoxic, less volatile liquid that can be stored and handled more safely than ammonia. Urea solution droplets can penetrate farther into the flue gas when injected into the boiler, enhancing mixing (EPA, 2002). Because of these advantages, urea is more commonly used than ammonia in large boiler applications.

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include:

Reaction temperature range;
Residence time available in the optimum temperature range;
Degree of mixing between the injected reagent and the combustion gases
Uncontrolled NO_x concentration level;
Molar ratio of injected reagent to uncontrolled NO_x ; and
Ammonia slip.

AT-A-GLANCE TABLE FOR POINT SOURCES

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Glass Manufacturing," EPA,-453/R-94-037, Research Triangle Park, NC, June 1994.

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Process Heaters," EPA,-453/R-93-034, Research Triangle Park, NC, September 1993.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Glass Manufacturing - Flat - Small Sources

Control Measure Name: Selective Catalytic Reduction (SCR)

Rule Name: Not Applicable

Pechan Measure Code: N0314S

POD: 31

Application: This control is the selective catalytic reduction of NOx through add-on controls. SCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NOx) into molecular nitrogen (N2) and water vapor (H2O). The SCR utilizes a catalyst to increase the NOx removal efficiency, which allows the process to occur at lower temperatures.

Applies to small (<1 ton NOx per OSD) flat-glass manufacturing operations (SCC 30501403) with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

30501403 Mineral Products, Glass Manufacture, Flat Glass: Melting Furnace

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 75% from uncontrolled

Equipment Life: 10 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NOx emission levels (Pechan, 1998).

Small source = emission levels less than 1 ton per ozone season day

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 10 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than 70% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown is estimated by applying percentages of O&M breakdown for SCR as applied to process heaters, using detailed information found in Table 6-3 and Chapter 6 of the Process Heater ACT document. The breakdown was obtained using the O&M costs for a 750 ton per day furnace.

Electricity: \$0.06 per kw-hr

Fuel (nat gas): \$2.00 per MMBTU

Ammonia: \$0.125 per lb

AT-A-GLANCE TABLE FOR POINT SOURCES

Cost Effectiveness: The cost effectiveness values used in AirControlNET are \$3,370 per ton NOx reduced from both uncontrolled and RACT baselines (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

Selective Catalytic Reduction (SCR) has been widely applied to stationary source, fossil fuel-fired, combustion units for emission control since the early 1970s. SCR is typically implemented on units requiring a higher level of NOx control than achievable by SNCR or other combustion controls (EPA, 2002).

Like SNCR, SCR is based on the chemical reduction of the NOx molecule. The primary difference between SNCR and SCR is that SCR uses a metal-based catalyst to increase the rate of reaction (EPA, 2002). A nitrogen based reducing reagent, such as ammonia or urea, is injected into the flue gas. The reagent reacts selectively with the flue gas NOx within a specific temperature range and in the presence of the catalyst and oxygen to reduce the NOx.

The use of a catalyst results in two advantages of the SCR process over SNCR, the higher NOx reduction efficiency and the lower and broader temperature ranges. However, the decrease in reaction temperature and increase in efficiency is accompanied by a significant increase in capital and operating costs (EPA, 2002). The cost increase is due to the large amount of catalyst required.

The SCR system can utilize either aqueous or anhydrous ammonia as the reagent. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Today, catalyst formulations include single component, multi-component, or active phase with a support structure. Most catalyst formulations contain additional compounds or supports, providing thermal and structural stability or to increase surface area (EPA, 2002).

The rate of reaction determines the amount of NOx removed from the flue gas. The important design and operational factors that affect the rate of reduction include: reaction temperature range; residence time available in the optimum temperature range; degree of mixing between the injected reagent and the combustion gases; uncontrolled NOx concentration level; molar ratio of injected reagent to uncontrolled NOx; ammonia slip; catalyst activity; catalyst selectivity; pressure drop across the catalyst; catalyst pitch; catalyst deactivation; and catalyst management (EPA, 2001).

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Glass Manufacturing," EPA,-453/R-94-037, Research Triangle Park, NC, June 1994.

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Process Heaters," EPA,-453/R-93-034, Research Triangle Park, NC, September 1993.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

AT-A-GLANCE TABLE FOR POINT SOURCES

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Glass Manufacturing - Pressed

Control Measure Name: Electric Boost

Rule Name: Not Applicable

Pechan Measure Code: N0321S, N03201

POD: 32

Application: This control is the use of electric boost technologies to reduce NOx emissions from glass manufacturing operations.

This control applies to pressed glass manufacturing operations classified under SCC 30501403.

Affected SCC:

30501404 Glass Manufacture, Pressed and Blown Glass: Melting Furnace

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√/*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 10% from uncontrolled

Equipment Life: 10 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The basis of the costs are model plant data contained in the Alternative Control Techniques (ACT) document (EPA, 1994). Capital, and annual cost information that was obtained from control-specific cost data based on tons of glass produced. O&M costs were back calculated from annual costs. From these determinations, default cost per ton values were assigned along with a capital to annual cost ratio of 4.5. A discount rate of 10 percent and a capacity factor of 65 percent are assumed, along with an equipment lifetime of 10 years (EPA, 1994).

Cost Effectiveness: The default cost effectiveness value used in AirControlNET is \$8,760 per ton NOx reduced from both uncontrolled and RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 1998

Additional Information:

The 50 tons per day plant is assumed to be representative of pressed glass plants (Pechan, 1998).

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Glass Manufacturing," EPA-453/R-94-037, Research Triangle Park, NC, June 1994.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle

AT-A-GLANCE TABLE FOR POINT SOURCES

Park, NC, September 1998.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Glass Manufacturing - Pressed

Control Measure Name: Cullet Preheat

Rule Name: Not Applicable

Pechan Measure Code: N0322S, N03202

POD: 32

Application: This control is the use of cullet preheat technologies to reduce NOx emissions from glass manufacturing operations.

This control is applicable to pressed glass manufacturing operations classified under 305010404.

Affected SCC:

30501404 Glass Manufacture, Pressed and Blown Glass: Melting Furnace

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 25% from uncontrolled

Equipment Life: 10 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The basis of the costs are model plant data contained in the Alternative Control Techniques (ACT) document (EPA, 1994). Capital and annual cost information is obtained from control-specific cost data based on tons of glass produced. O&M costs were back calculated from annual costs. From these determinations, default cost per ton values were assigned along with a capital to annual cost ratio of 4.5 (Pechan, 1998). A discount rate of 10 percent and a capacity factor of 65 percent are assumed, along with an equipment lifetime of 10 years (EPA, 1994).

Cost Effectiveness: The default cost effectiveness value used in AirControlNET is \$810 per ton NOx reduced from both uncontrolled and RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 1998

Additional Information:

The 50 tons per day plant is assumed to be representative of pressed glass plants (Pechan, 1998).

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Glass Manufacturing," EPA-453/R-94-037, Research Triangle Park, NC, June 1994.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle

AT-A-GLANCE TABLE FOR POINT SOURCES

Park, September 1998.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Glass Manufacturing - Pressed

Control Measure Name: Low NOx Burner

Rule Name: Not Applicable

Pechan Measure Code: N0323S, N03203

POD: 32

Application: This control is the use of low NOx burner (LNB) technology to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another.

This control is applicable to pressed glass manufacturing operations classified under 305010404 with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

30501404 Glass Manufacture, Pressed and Blown Glass: Melting Furnace

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 40% from uncontrolled

Equipment Life: 10 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The basis of the costs are model plant data contained in the Alternative Control Techniques (ACT) document (EPA, 1994). Capital and annual cost information is obtained from control-specific cost data based on tons of glass produced. O&M costs were back calculated from annual costs. From these determinations, default cost per ton values were assigned along with a capital to annual cost ratio of 2.2 (Pechan, 1998). A discount rate of 10 percent and a capacity factor of 65 percent are assumed, along with an equipment lifetime of 10 years (EPA, 1994).

Cost Effectiveness: The default cost effectiveness value used in AirControlNET is \$1,500 per ton NOx reduced from both uncontrolled and RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 1998

Additional Information:

The 500 tons per day plant is assumed to be representative of flat glass plants (Pechan, 1998).

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNBs create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNBs create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

AT-A-GLANCE TABLE FOR POINT SOURCES

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Glass Manufacturing," EPA,-453/R-94-037, Research Triangle Park, NC, June 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 1998.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Glass Manufacturing - Pressed

Control Measure Name: Selective Non-Catalytic Reduction (SNCR)

Rule Name: Not Applicable

Pechan Measure Code: N0324S, N03204

POD: 32

Application: This control is the reduction of NO_x emission through selective non-catalytic reduction add-on controls. SNCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NO_x) into molecular nitrogen (N₂) and water vapor (H₂O).

This control applies to pressed-glass manufacturing operations (SCC 30501404) with uncontrolled NO_x emissions greater than 10 tons per year.

Affected SCC:

30501404 Glass Manufacture, Pressed and Blown Glass: Melting Furnace

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 40% from uncontrolled

Equipment Life: 10 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NO_x emission levels (Pechan, 1998).

Small source = emission levels less than 1 ton per ozone season day

Large source = emission levels greater than 1 ton per ozone season day

Costs for stationary source NO_x control are based on an analysis of EPA's NO_x State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 10 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than 70% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown is estimated by applying percentages of O&M breakdown for SNCR as applied to process heaters, using detailed information found in Table 6-3 and Chapter 6 of the Process Heater ACT document. The breakdown was obtained using the O&M costs for a 50 ton per day furnace.

Electricity: \$0.06 per kw-hr

Fuel (nat gas): \$2.00 per MMBTU

Ammonia: \$0.125 per lb

AT-A-GLANCE TABLE FOR POINT SOURCES

Cost Effectiveness: The cost effectiveness (for both small and large sources) used in AirControlNET for both reductions from baseline and reductions from RACT is \$1,640 per ton NO_x reduced (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

SNCR is the reduction of NO_x in flue gas to N₂ and water vapor. This reduction is done with a nitrogen based reducing reagent, such as ammonia or urea. The reagent can react with a number of flue gas components. However, the NO_x reduction reaction is favored for a specific temperature range and in the presence of oxygen (EPA, 2002).

Both ammonia and urea are used as reagents. The cost of the reagent represents a large part of the annual costs of an SNCR system. Ammonia is generally less expensive than urea. However, the choice of reagent is also based on physical properties and operational considerations (EPA, 2002).

Ammonia can be utilized in either aqueous or anhydrous form. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Urea based systems have several advantages, including several safety aspects. Urea is a nontoxic, less volatile liquid that can be stored and handled more safely than ammonia. Urea solution droplets can penetrate farther into the flue gas when injected into the boiler, enhancing mixing (EPA, 2002). Because of these advantages, urea is more commonly used than ammonia in large boiler applications.

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include:

Reaction temperature range;
Residence time available in the optimum temperature range;
Degree of mixing between the injected reagent and the combustion gases
Uncontrolled NO_x concentration level;
Molar ratio of injected reagent to uncontrolled NO_x ; and
Ammonia slip..

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Glass Manufacturing," EPA,-453/R-94-037, Research Triangle Park, NC, June 1994..

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Process Heaters," EPA,-453/R-93-034, Research Triangle Park, NC, September 1993.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity

AT-A-GLANCE TABLE FOR POINT SOURCES

Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Glass Manufacturing - Pressed

Control Measure Name: Selective Catalytic Reduction (SCR)

Rule Name: Not Applicable

Pechan Measure Code: N0325S, N03205

POD: 32

Application: This control is the selective catalytic reduction of NO_x through add-on controls. SCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NO_x) into molecular nitrogen (N₂) and water vapor (H₂O). The SCR utilizes a catalyst to increase the NO_x removal efficiency, which allows the process to occur at lower temperatures.

Applies to pressed-glass manufacturing operations, classified under SCC 30101404 and uncontrolled NO_x emissions greater than 10 tons per year.

Affected SCC:

30501404 Glass Manufacture, Pressed and Blown Glass: Melting Furnace

Pollutant(s)	PM10	PM2.5	EC	OC	NO _x	VOC	SO ₂	NH ₃	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 75% from uncontrolled

Equipment Life: 10 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NO_x emission levels (Pechan, 1998).

Small source = emission levels less than 1 ton per ozone season day

Large source = emission levels greater than 1 ton per ozone season day

Costs for stationary source NO_x control are based on an analysis of EPA's NO_x State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values and a capital to annual cost ratio of 1.3 are assigned. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 10 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than 70% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown is estimated by applying percentages of O&M breakdown for SCR as applied to process heaters, using detailed information found in Table 6-3 and Chapter 6 of the Process Heater ACT document. The breakdown was obtained using the O&M costs for a 50 ton per day furnace.

Electricity: \$0.06 per kw-hr

Fuel (nat gas): \$2.00 per MMBTU

AT-A-GLANCE TABLE FOR POINT SOURCES

Ammonia: \$0.125 per lb

Cost Effectiveness: The cost effectiveness value (for both small and large sources) used in AirControlNET is \$2,530 per ton NO_x reduced from both uncontrolled and RACT baselines (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

Selective Catalytic Reduction (SCR) has been widely applied to stationary source, fossil fuel-fired, combustion units for emission control since the early 1970s. SCR is typically implemented on units requiring a higher level of NO_x control than achievable by SNCR or other combustion controls (EPA, 2002).

Like SNCR, SCR is based on the chemical reduction of the NO_x molecule. The primary difference between SNCR and SCR is that SCR uses a metal-based catalyst to increase the rate of reaction (EPA, 2002). A nitrogen based reducing reagent, such as ammonia or urea, is injected into the flue gas. The reagent reacts selectively with the flue gas NO_x within a specific temperature range and in the presence of the catalyst and oxygen to reduce the NO_x.

The use of a catalyst results in two advantages of the SCR process over SNCR, the higher NO_x reduction efficiency and the lower and broader temperature ranges. However, the decrease in reaction temperature and increase in efficiency is accompanied by a significant increase in capital and operating costs (EPA, 2002). The cost increase is due to the large amount of catalyst required.

The SCR system can utilize either aqueous or anhydrous ammonia as the reagent. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Today, catalyst formulations include single component, multi-component, or active phase with a support structure. Most catalyst formulations contain additional compounds or supports, providing thermal and structural stability or to increase surface area (EPA, 2002).

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include: reaction temperature range; residence time available in the optimum temperature range; degree of mixing between the injected reagent and the combustion gases; uncontrolled NO_x concentration level; molar ratio of injected reagent to uncontrolled NO_x; ammonia slip; catalyst activity; catalyst selectivity; pressure drop across the catalyst; catalyst pitch; catalyst deactivation; and catalyst management (EPA, 2001).

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Glass Manufacturing," EPA-453/R-94-037, Research Triangle Park, NC, June 1994.

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Process Heaters," EPA-453/R-93-034, Research Triangle Park, NC, September 1993.

AT-A-GLANCE TABLE FOR POINT SOURCES

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Glass Manufacturing - Pressed

Control Measure Name: OXY-Firing

Rule Name: Not Applicable

Pechan Measure Code: N0326S, N03206

POD: 32

Application: This control is the use of OXY-firing to reduce NOx emissions.

This control applies to pressed-glass manufacturing operations with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

30501404 Glass Manufacture, Pressed and Blown Glass: Melting Furnace

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 85% from uncontrolled

Equipment Life: 10 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The basis of the costs are model plant data contained in the Alternative Control Techniques (ACT) document (EPA, 1994). Capital and annual cost information is obtained from control-specific cost data based on tons of glass produced. O&M costs were back calculated from annual costs. From these determinations, default cost per ton values were assigned along with a capital to annual cost ratio of 2.7 (Pechan, 1998). A discount rate of 10 percent and a capacity factor of 65 percent are assumed, along with an equipment lifetime of 10 years (EPA, 1994).

Cost Effectiveness: The default cost effectiveness value is \$3,900 per ton NOx reduced from both uncontrolled and RACT baselines (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

The 50 tons per day plant is assumed to be representative of pressed glass plants (Pechan, 1998).

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Glass Manufacturing," EPA,-453/R-94-037, Research Triangle Park, NC, June 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

AT-A-GLANCE TABLE FOR POINT SOURCES

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 1998.

AT-A-GLANCE TABLE FOR MOBILE SOURCES

Source Category: Highway Vehicles - Gasoline Engine

Control Measure Name: Low Reid Vapor Pressure (RVP) Limit in Ozone Season

Rule Name: Not Applicable

Pechan Measure Code: mOT8

POD: N/A

Application: This control measure represents the use of reformulated gasoline to have a RVP limit of 7.8 psi from May through September in counties with an ozone season RVP value greater than 7.8 psi. Emission reduction benefits of NO_x, CO, and VOC are estimated using EPA's MOBILE6 model.

This control is applicable to all light duty gasoline vehicles, motor cycles, and trucks.

Affected SCC:

2201001000 Light Duty Gasoline Vehicles (LDGV), Total: All Road Types

2201020000 Light Duty Gasoline Trucks 1 (LDGT1), Total: All Road Types

2201040000 Light Duty Gasoline Trucks 2 (LDGT2), Total: All Road Types

2201070000 Heavy Duty Gasoline Vehicles (HDGV), Total: All Road Types

2201080000 Motorcycles (MC), Total: All Road Types

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√	√*			√	

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: The control efficiency ranged from: NO_x (-1.1 to 0.6%; VOC (0.1 to 11.1%); CO (0.0 to 6.1%)

Equipment Life: Not Applicable

Rule Effectiveness: Not applicable

Penetration: Not applicable

Cost Basis: The calculate are calculated based of the number of vehicles and amount of fuel consumed form May through September by county and vehicle type. Costs were estimated on a per-vehicle basis.

The number of vehicles was estimated by dividing the VMT by the average LDGV annual mileage accumulation rate. The costs estimated at \$0.0036 * 5 /12 per gallon (Pechan 2002). All costs are \$1997.

Cost Effectiveness: The cost effectiveness of a 7.8 RVP limit varies greatly by county. Cost effectiveness for VOC ranged from \$25,671 to \$125 per ton. The average C-E for VOC is \$1,548 per ton of VOC reduced (median is \$1,560 per ton). All costs are \$1997.

Comments: In some cases this control produces a slight NO_x disbenefit.

Status: Demonstrated

Last Reviewed: 2002

Additional Information:

References:

Pechan 2002: "AirControlINET Specifications and Methods for Mobile Source Controls" Memo prepared for Larry Sorrels of the US EPA, December 2002.

AT-A-GLANCE TABLE FOR MOBILE SOURCES

Source Category: Highway Vehicles - Heavy Duty and Diesel-Fueled Vehicles

Control Measure Name: Heavy Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Controls

Rule Name: Heavy Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Standards

Pechan Measure Code: HDD10

POD: N/A

Application: This control measure represents the application of EPA's heavy duty engine and vehicle standards and highway diesel fuel sulfur control requirements in 1999. Emissions reduction benefits of NOx, PM10, PM2.5, VOC, CO and SO2 are estimated using EPA's MOBILE6 model.

This control is applicable to all heavy duty diesel vehicles beginning with the 2007 model year, and all heavy duty gasoline vehicles beginning with the 2008 model year. Light duty gasoline vehicles and motorcycles are not affected by this control.

Affected SCC:

2201070000 Heavy Duty Gasoline Vehicles (HDGV), Total: All Road Types
2230070000 Heavy Duty Diesel Vehicles (HDDV), Total: All Road Types
2230001000 Light Duty Diesel Vehicles (LDDV), Total: All Road Types
2230060000 Light Duty Diesel Trucks (LDDT), Total: All Road Types

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√	√			√*	√	√		√	

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: The control efficiencies varies for each vehicle type:

HDG: PM2.5 (11%); PM10 (9%); NOx (19%); VOC (2%); SO2 (1%); CO (5%)

HDD: PM2.5 (19%); PM10 (18%); NOx (33%); VOC (12%); SO2 (97%); CO (22%)

LDD: PM2.5 (2-4%); PM10 (2-4%); NOx (0%); VOC (0%); SO2 (97%); CO (0%)

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: To calculate costs for the heavy duty engine and vehicle standards, an estimate was made of the number of vehicles affected by the control. The number of vehicles was estimated by dividing the VMT by the average annual mileage accumulation rate for each affected vehicle type and model year. The costs for the heavy duty engine and vehicle standards are estimated at \$1,940.92 per heavy duty gasoline vehicle and \$2,712.89 per heavy duty diesel vehicle (EPA, 2000). All costs are in 1999 dollars.

The costs for the highway diesel fuel sulfur controls were applied to all gallons of diesel fuel used by the affected vehicles (LDDV, LDDT, and HDDV). Low sulfur diesel fuel is estimated to cost an additional \$0.05 per gallon of diesel fuel (EPA, 2000). All costs are in 1999 dollars.

Cost Effectiveness: The cost effectiveness of the heavy duty engine and vehicle standards and highway diesel fuel sulfur controls varies greatly by county and depends mostly on the number of vehicles and the year modeled. Cost effectiveness ranged

AT-A-GLANCE TABLE FOR MOBILE SOURCES

from \$2,414 to \$22,859 per ton NOx reduced. The average value used in AirControlNET is \$9,301.05 per ton NOx reduced. All costs are \$1999.

Comments:

Status: Demonstrated	Last Reviewed: 2003
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Additional Information:

References:

EPA, 2000: U.S. Environmental Protection Agency, "Regulatory Impact Analysis: Control of Emissions of Air Pollution from Highway Heavy-Duty Engines." EPA420-R-00-010, July 2000.

AT-A-GLANCE TABLE FOR MOBILE SOURCES

Source Category: Highway Vehicles - Heavy Duty and Diesel-Fueled Vehicles

Control Measure Name: Heavy Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Controls

Rule Name: Heavy Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Standards

Pechan Measure Code: HDD15

POD: N/A

Application: This control measure represents the application of EPA's heavy duty engine and vehicle standards and highway diesel fuel sulfur control requirements in 1999. Emissions reduction benefits of NOx, PM10, PM2.5, VOC, CO and SO2 are estimated using EPA's MOBILE6 model.

This control is applicable to all heavy duty diesel vehicles beginning with the 2007 model year, and all heavy duty gasoline vehicles beginning with the 2008 model year. Light duty gasoline vehicles and motorcycles are not affected by this control.

Affected SCC:

2201070000 Heavy Duty Gasoline Vehicles (HDGV), Total: All Road Types

2230070000 Heavy Duty Diesel Vehicles (HDDV), Total: All Road Types

2230001000 Light Duty Diesel Vehicles (LDDV), Total: All Road Types

2230060000 Light Duty Diesel Trucks (LDDT), Total: All Road Types

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√	√			√*	√	√		√	

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: The control efficiencies varies for each vehicle type:

HDG: PM2.5 (25%); PM10 (21%); NOx (44%); VOC (11%); SO2 (99%); CO (13%)

HDD: PM2.5 (39%); PM10 (37%); NOx (68%); VOC (26%); SO2 (97%); CO (41%)

LDD: PM2.5 (2-4%); PM10 (2-4%); NOx (0%); VOC (0%); SO2 (97%); CO (0%)

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: To calculate costs for the heavy duty engine and vehicle standards, an estimate was made of the number of vehicles affected by the control. The number of vehicles was estimated by dividing the VMT by the average annual mileage accumulation rate for each affected vehicle type and model year. The costs for the heavy duty engine and vehicle standards are estimated at \$1,940.92 per heavy duty gasoline vehicle and \$2,712.89 per heavy duty diesel vehicle (EPA, 2000). All costs are in 1999 dollars.

The costs for the highway diesel fuel sulfur controls were applied to all gallons of diesel fuel used by the affected vehicles (LDDV, LDDT, and HDDV). Low sulfur diesel fuel is estimated to cost an additional \$0.05 per gallon of diesel fuel (EPA, 2000). All costs are in 1999 dollars.

Cost Effectiveness: The cost effectiveness of the heavy duty engine and vehicle standards and highway diesel fuel sulfur controls varies greatly by county and depends mostly

AT-A-GLANCE TABLE FOR MOBILE SOURCES

on the number of vehicles and the year modeled. Cost effectiveness ranged from \$1,926 to \$26,499 per ton NOx reduced. The average value is \$10,560.58 per ton NOx reduced. All costs are \$1999.

Comments:

Status: Demonstrated	Last Reviewed: 2003
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Additional Information:

References:

EPA, 2000: U.S. Environmental Protection Agency, "Regulatory Impact Analysis: Control of Emissions of Air Pollution from Highway Heavy-Duty Engines." EPA420-R-00-010, July 2000.

AT-A-GLANCE TABLE FOR MOBILE SOURCES

Source Category: Highway Vehicles - Heavy Duty and Diesel-Fueled Vehicles

Control Measure Name: Heavy Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Controls

Rule Name: Heavy Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Standards

Pechan Measure Code: HDD20

POD: N/A

Application: This control measure represents the application of EPA's heavy duty engine and vehicle standards and highway diesel fuel sulfur control requirements in 1999. Emissions reduction benefits of NOx, PM10, PM2.5, VOC, CO and SO2 are estimated using EPA's MOBILE6 model.

This control is applicable to all heavy duty diesel vehicles beginning with the 2007 model year, and all heavy duty gasoline vehicles beginning with the 2008 model year. Light duty gasoline vehicles and motorcycles are not affected by this control.

Affected SCC:

2201070000 Heavy Duty Gasoline Vehicles (HDGV), Total: All Road Types

2230070000 Heavy Duty Diesel Vehicles (HDDV), Total: All Road Types

2230001000 Light Duty Diesel Vehicles (LDDV), Total: All Road Types

2230060000 Light Duty Diesel Trucks (LDDT), Total: All Road Types

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√	√			√*	√	√		√	

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: The control efficiencies varies for each vehicle type:

HDG: PM2.5 (32%); PM10 (28%); NOx (61%); VOC (21%); SO2 (100%); CO (19%)

HDD: PM2.5 (70%); PM10 (67%); NOx (85%); VOC (43%); SO2 (97%); CO (66%)

LDD: PM2.5 (2-4%); PM10 (2-4%); NOx (0%); VOC (0%); SO2 (97%); CO (0%)

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: To calculate costs for the heavy duty engine and vehicle standards, an estimate was made of the number of vehicles affected by the control. The number of vehicles was estimated by dividing the VMT by the average annual mileage accumulation rate for each affected vehicle type and model year. The costs for the heavy duty engine and vehicle standards are estimated at \$1,940.92 per heavy duty gasoline vehicle and \$2,712.89 per heavy duty diesel vehicle (EPA, 2000). All costs are in 1999 dollars.

The costs for the highway diesel fuel sulfur controls were applied to all gallons of diesel fuel used by the affected vehicles (LDDV, LDDT, and HDDV). Low sulfur diesel fuel is estimated to cost an additional \$0.05 per gallon of diesel fuel (EPA, 2000). All costs are in 1999 dollars.

Cost Effectiveness: The cost effectiveness of the heavy duty engine and vehicle standards and highway diesel fuel sulfur controls varies greatly by county and depends mostly

AT-A-GLANCE TABLE FOR MOBILE SOURCES

on the number of vehicles and the year modeled. Cost effectiveness ranged from \$2,131 to \$29,408 per ton NOx reduced. The average value is \$11,955.65 per ton NOx reduced. All costs are \$1999.

Comments:

Status: Demonstrated	Last Reviewed: 2003
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Additional Information:

References:

EPA, 2000: U.S. Environmental Protection Agency, "Regulatory Impact Analysis: Control of Emissions of Air Pollution from Highway Heavy-Duty Engines." EPA420-R-00-010, July 2000.

AT-A-GLANCE TABLE FOR MOBILE SOURCES

Source Category: Highway Vehicles - Heavy Duty and Diesel-Fueled Vehicles

Control Measure Name: Heavy Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Controls

Rule Name: Heavy Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Standards

Pechan Measure Code: HDD30

POD: N/A

Application: This control measure represents the application of EPA's heavy duty engine and vehicle standards and highway diesel fuel sulfur control requirements in 1999. Emissions reduction benefits of NOx, PM10, PM2.5, VOC, CO and SO2 are estimated using EPA's MOBILE6 model.

This control is applicable to all heavy duty diesel vehicles beginning with the 2007 model year, and all heavy duty gasoline vehicles beginning with the 2008 model year. Light duty gasoline vehicles and motorcycles are not affected by this control.

Affected SCC:

2201070000 Heavy Duty Gasoline Vehicles (HDGV), Total: All Road Types

2230070000 Heavy Duty Diesel Vehicles (HDDV), Total: All Road Types

2230001000 Light Duty Diesel Vehicles (LDDV), Total: All Road Types

2230060000 Light Duty Diesel Trucks (LDDT), Total: All Road Types

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√	√			√*	√	√		√	

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: The control efficiencies varies for each vehicle type:

HDG: PM2.5 (53%); PM10 (52%); NOx (76%); VOC (61%); SO2 (103%); CO (63%)

HDD: PM2.5 (91%); PM10 (87%); NOx (95%); VOC (63%); SO2 (97%); CO (91%)

LDD: PM2.5 (2-4%); PM10 (2-4%); NOx (0%); VOC (0%); SO2 (97%); CO (0%)

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: To calculate costs for the heavy duty engine and vehicle standards, an estimate was made of the number of vehicles affected by the control. The number of vehicles was estimated by dividing the VMT by the average annual mileage accumulation rate for each affected vehicle type and model year. The costs for the heavy duty engine and vehicle standards are estimated at \$1,940.92 per heavy duty gasoline vehicle and \$2,712.89 per heavy duty diesel vehicle (EPA, 2000). All costs are in 1999 dollars.

The costs for the highway diesel fuel sulfur controls were applied to all gallons of diesel fuel used by the affected vehicles (LDDV, LDDT, and HDDV). Low sulfur diesel fuel is estimated to cost an additional \$0.05 per gallon of diesel fuel (EPA, 2000). All costs are in 1999 dollars.

Cost Effectiveness: The cost effectiveness of the heavy duty engine and vehicle standards and highway diesel fuel sulfur controls varies greatly by county and depends mostly

AT-A-GLANCE TABLE FOR MOBILE SOURCES

on the number of vehicles and the year modeled. Cost effectiveness ranged from \$2,229 to \$38,254 per ton NOx reduced. The average value is \$16,108.48 per ton NOx reduced. All costs are \$1999.

Comments:

Status: Demonstrated	Last Reviewed: 2003
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Additional Information:

References:

EPA, 2000: U.S. Environmental Protection Agency, "Regulatory Impact Analysis: Control of Emissions of Air Pollution from Highway Heavy-Duty Engines." EPA420-R-00-010, July 2000.

AT-A-GLANCE TABLE FOR MOBILE SOURCES

Source Category: Highway Vehicles - Heavy Duty Diesel Engines

Control Measure Name: Voluntary Diesel Retrofit Program: Selective Catalytic Reduction

Rule Name: Not Applicable

Pechan Measure Code: HDR399

POD:

Application: This control measure represents the application of EPA's voluntary diesel retrofit program through the use of selective catalytic reduction as a retrofit technology in 1999. Emissions reduction benefits of NOX, CO, VOC, PM10, PM2.5, and SO2 are estimated using EPA's MOBILE6 model and independent research on the percent reductions yielded by this control measure.

This control is applicable to all heavy duty diesel vehicles. Light duty and gasoline-fueled vehicles are not affected by this control.

Affected SCC:

2230070000 Heavy Duty Diesel Vehicles (HDDV), Total: All Road Types

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√	√			√*	√	√		√	

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: The control efficiency varies by pollutant: NOx (75%); PM10 (19.26%); PM2.5 (19.8%); VOC (70%); SO2 (97%); CO (70%)

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: To calculate costs for the use of selective catalytic reduction as a retrofit technology, the assumption was made that all relevant vehicles would be affected by the control. Therefore, all heavy duty diesel vehicles were assumed to employ selective catalytic reduction as a retrofit technology through the voluntary diesel retrofit program. The average cost of a selective catalytic reduction system ranges from \$10,000 to \$20,000 per vehicle depending on the size of the engine, the sales volume, and other factors (Pechan, 2003). For this AirControlNET analysis, the average estimated cost of this system is \$15,000 per heavy duty diesel vehicle.

Selective catalytic reduction requires the use of low sulfur diesel fuel. The costs for the low sulfur diesel fuel were applied to all gallons of diesel fuel used by the heavy duty diesel vehicles. Low sulfur diesel fuel is estimated to cost an additional \$0.05 per gallon of diesel (EPA, 2000). All costs are in 1999 dollars.

Cost Effectiveness: The cost effectiveness of selective catalytic reduction varies greatly by county and depends mostly on the number of vehicles. Cost effectiveness for NOX fell within the following range: \$13,499 to \$56,474 per ton NOx reduced. The average cost effectiveness used in AirControlNET is \$50,441.54 per ton NOX reduced. All costs are in \$1999.

Comments:

AT-A-GLANCE TABLE FOR MOBILE SOURCES

Status: Demonstrated	Last Reviewed: 2003
Additional Information:	

References:

EPA, 2000: U.S. Environmental Protection Agency, "Regulatory Impact Analysis: Control of Emissions of Air Pollution from Highway Heavy-Duty Engines." EPA420-R-00-010, July 2000.

Pechan, 2003. E.H. Pechan & Associates, Inc., "Methodology to Implement Voluntary Diesel Retrofit Program in AirControlNET," Memo prepared for Tyler Fox of the US EPA, July 2003.

AT-A-GLANCE TABLE FOR MOBILE SOURCES

Source Category: Highway Vehicles - Light Duty and Gasoline-Fueled Vehicles

Control Measure Name: Tier 2 Motor Vehicle Emissions and Gasoline Sulfur Controls

Rule Name: Tier 2 Motor Vehicle Emissions and Gasoline Sulfur Standards

Pechan Measure Code: T210

POD: N/A

Application: This control measure represents the application of EPA's Tier 2 motor vehicle emissions and gasoline fuel sulfur control requirements in 1999. Emissions reduction benefits of NOx, PM10-2.5, PM2.5, VOC, CO and SO2 are estimated using EPA's MOBILE6 model.

This control is applicable to all light duty vehicles beginning with the 2004 model year, and all gasoline vehicles beginning with the 1981 model year. Heavy duty diesel vehicles and motorcycles are not affected by this control.

Affected SCC:

2201001000 Light Duty Gasoline Vehicles (LDGV), Total: All Road Types
2201020000 Light Duty Gasoline Trucks 1 (LDGT1), Total: All Road Types
2201040000 Light Duty Gasoline Trucks 2 (LDGT2), Total: All Road Types
2201070000 Heavy Duty Gasoline Vehicles (HDGV), Total: All Road Types
2230001000 Light Duty Diesel Vehicles (LDDV), Total: All Road Types
2230060000 Light Duty Diesel Trucks (LDDT), Total: All Road Types

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√	√			√*	√	√		√	

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: The control efficiencies varies for each vehicle type:

LDG: PM2.5 (23-32%); PM10 (15-19%); NOx (28-40%); VOC (12-23%); SO2 (90%); CO (13-25%)

HDG: PM2.5 (8%); PM10 (6%); NOx (2%); VOC (5%); SO2 (90%); CO (4%)

LDD: PM2.5 (4-27%); PM10 (4-26%); NOx (7-35%); VOC (3-26%); SO2 (0%); CO (2-21%)

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: To calculate costs for the Tier 2 motor vehicle emissions standards, an estimate was made of the number of vehicles affected by the control. The number of vehicles was estimated by dividing the VMT by the average annual mileage accumulation rate for each affected vehicle type and model year. The costs for the Tier 2 motor vehicle emissions standards are estimated at \$82.43 per light duty gasoline vehicle and light duty diesel truck, \$116.66 per light duty gasoline truck 1, \$210.51 per light duty diesel truck, and \$252.90 per light duty gasoline truck 2 (EPA, 1999). All costs are in 1999 dollars.

The costs for the gasoline fuel sulfur controls were applied to all gallons of gasoline fuel used by the affected vehicles (LDGV, LDGT1, LDGT2, HDGV). Low sulfur gasoline fuel is estimated to cost an additional \$0.0193 per gallon of gasoline (EPA, 1999). All costs are in 1999 dollars.

AT-A-GLANCE TABLE FOR MOBILE SOURCES

Cost Effectiveness: The cost effectiveness of the Tier 2 motor vehicle emissions and gasoline fuel sulfur control requirements varies greatly by county and depends mostly on the number of vehicles and the year modeled. Cost effectiveness ranged from \$1,108 to \$11,221 per ton NOx reduced. The average value used in AirControlNET is \$6,269.63 per ton NOx reduced. All costs are \$1999.

Comments:

Status: Demonstrated

Last Reviewed: 2003

Additional Information:

References:

EPA, 1999: U.S. Environmental Protection Agency, "Regulatory Impact Analysis - Control of Air Pollution from New Motor Vehicles: Tier 2 Motor Vehicle Emissions Standards and Gasoline Sulfur Control Requirements," EPA420-R-99-023, December 1999.

AT-A-GLANCE TABLE FOR MOBILE SOURCES

Source Category: Highway Vehicles - Light Duty and Gasoline-Fueled Vehicles

Control Measure Name: Tier 2 Motor Vehicle Emissions and Gasoline Sulfur Controls

Rule Name: Tier 2 Motor Vehicle Emissions and Gasoline Sulfur Standards

Pechan Measure Code: T215

POD: N/A

Application: This control measure represents the application of EPA's Tier 2 motor vehicle emissions and gasoline fuel sulfur control requirements in 1999. Emissions reduction benefits of NOx, PM10-2.5, PM2.5, VOC, CO and SO2 are estimated using EPA's MOBILE6 model.

This control is applicable to all light duty vehicles beginning with the 2004 model year, and all gasoline vehicles beginning with the 1981 model year. Heavy duty diesel vehicles and motorcycles are not affected by this control.

Affected SCC:

2201001000 Light Duty Gasoline Vehicles (LDGV), Total: All Road Types
2201020000 Light Duty Gasoline Trucks 1 (LDGT1), Total: All Road Types
2201040000 Light Duty Gasoline Trucks 2 (LDGT2), Total: All Road Types
2201070000 Heavy Duty Gasoline Vehicles (HDGV), Total: All Road Types
2230001000 Light Duty Diesel Vehicles (LDDV), Total: All Road Types
2230060000 Light Duty Diesel Trucks (LDDT), Total: All Road Types

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√	√			√*	√	√		√	

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: The control efficiencies varies for each vehicle type:

LDG: PM2.5 (25-35%); PM10 (16-21%); NOx (43-66%); VOC (21-43%); SO2 (90%); CO (20-41%)

HDG: PM2.5 (12%); PM10 (10%); NOx (9%); VOC (8%); SO2 (90%); CO (6%)

LDD: PM2.5 (6-45%); PM10 (6-43%); NOx (11-49%); VOC (7-42%); SO2 (0%); CO (4-33%)

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: To calculate costs for the Tier 2 motor vehicle emissions standards, an estimate was made of the number of vehicles affected by the control. The number of vehicles was estimated by dividing the VMT by the average annual mileage accumulation rate for each affected vehicle type and model year. The costs for the Tier 2 motor vehicle emissions standards are estimated at \$82.43 per light duty gasoline vehicle and light duty diesel truck, \$116.66 per light duty gasoline truck 1, \$210.51 per light duty diesel truck, and \$252.90 per light duty gasoline truck 2 (EPA, 1999). All costs are in 1999 dollars.

The costs for the gasoline fuel sulfur controls were applied to all gallons of gasoline fuel used by the affected vehicles (LDGV, LDGT1, LDGT2, HDGV). Low sulfur gasoline fuel is estimated to cost an additional \$0.0193 per gallon of gasoline (EPA, 1999). All costs are in 1999 dollars.

AT-A-GLANCE TABLE FOR MOBILE SOURCES

Cost Effectiveness: The cost effectiveness of the Tier 2 motor vehicle emissions and gasoline fuel sulfur control requirements varies greatly by county and depends mostly on the number of vehicles and the year modeled. Cost effectiveness ranged from \$1,188 to \$12,609 per ton NOx reduced. The average value used in AirControlNET is \$6,135.41 per ton NOx reduced. All costs are \$1999.

Comments:

Status: Demonstrated

Last Reviewed: 2003

Additional Information:

References:

EPA, 1999: U.S. Environmental Protection Agency, "Regulatory Impact Analysis - Control of Air Pollution from New Motor Vehicles: Tier 2 Motor Vehicle Emissions Standards and Gasoline Sulfur Control Requirements," EPA420-R-99-023, December 1999.

AT-A-GLANCE TABLE FOR MOBILE SOURCES

Source Category: Highway Vehicles - Light Duty and Gasoline-Fueled Vehicles

Control Measure Name: Tier 2 Motor Vehicle Emissions and Gasoline Sulfur Controls

Rule Name: Tier 2 Motor Vehicle Emissions and Gasoline Sulfur Standards

Pechan Measure Code: T220

POD: N/A

Application: This control measure represents the application of EPA's Tier 2 motor vehicle emissions and gasoline fuel sulfur control requirements in 1999. Emissions reduction benefits of NOx, PM10-2.5, PM2.5, VOC, CO and SO2 are estimated using EPA's MOBILE6 model.

This control is applicable to all light duty vehicles beginning with the 2004 model year, and all gasoline vehicles beginning with the 1981 model year. Heavy duty diesel vehicles and motorcycles are not affected by this control.

Affected SCC:

2201001000 Light Duty Gasoline Vehicles (LDGV), Total: All Road Types
2201020000 Light Duty Gasoline Trucks 1 (LDGT1), Total: All Road Types
2201040000 Light Duty Gasoline Trucks 2 (LDGT2), Total: All Road Types
2201070000 Heavy Duty Gasoline Vehicles (HDGV), Total: All Road Types
2230001000 Light Duty Diesel Vehicles (LDDV), Total: All Road Types
2230060000 Light Duty Diesel Trucks (LDDT), Total: All Road Types

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√	√			√*	√	√		√	

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: The control efficiencies varies for each vehicle type:

LDG: PM2.5 (30-39%); PM10 (17-23%); NOx (52-77%); VOC (36-65%); SO2 (90%); CO (30-56%)

HDG: PM2.5 (14%); PM10 (12%); NOx (13%); VOC (11%); SO2 (90%); CO (8%)

LDD: PM2.5 (30-58%); PM10 (29-54%); NOx (40-61%); VOC (30-55%); SO2 (0-4%); CO (7-41%)

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: To calculate costs for the Tier 2 motor vehicle emissions standards, an estimate was made of the number of vehicles affected by the control. The number of vehicles was estimated by dividing the VMT by the average annual mileage accumulation rate for each affected vehicle type and model year. The costs for the Tier 2 motor vehicle emissions standards are estimated at \$82.43 per light duty gasoline vehicle and light duty diesel truck, \$116.66 per light duty gasoline truck 1, \$210.51 per light duty diesel truck, and \$252.90 per light duty gasoline truck 2 (EPA, 1999). All costs are in 1999 dollars.

The costs for the gasoline fuel sulfur controls were applied to all gallons of gasoline fuel used by the affected vehicles (LDGV, LDGT1, LDGT2, HDGV). Low sulfur gasoline fuel is estimated to cost an additional \$0.0193 per gallon of gasoline (EPA, 1999). All costs are in 1999 dollars.

AT-A-GLANCE TABLE FOR MOBILE SOURCES

Cost Effectiveness: The cost effectiveness of the Tier 2 motor vehicle emissions and gasoline fuel sulfur control requirements varies greatly by county and depends mostly on the number of vehicles and the year modeled. Cost effectiveness ranged from \$1,464 to \$16,235 per ton NOx reduced. The average value used in AirControlNET is \$6,933.40 per ton NOx reduced. All costs are \$1999.

Comments:

Status: Demonstrated

Last Reviewed: 2003

Additional Information:

References:

EPA, 1999: U.S. Environmental Protection Agency, "Regulatory Impact Analysis - Control of Air Pollution from New Motor Vehicles: Tier 2 Motor Vehicle Emissions Standards and Gasoline Sulfur Control Requirements," EPA420-R-99-023, December 1999.

AT-A-GLANCE TABLE FOR MOBILE SOURCES

Source Category: Highway Vehicles - Light Duty and Gasoline-Fueled Vehicles

Control Measure Name: Tier 2 Motor Vehicle Emissions and Gasoline Sulfur Controls

Rule Name: Tier 2 Motor Vehicle Emissions and Gasoline Sulfur Standards

Pechan Measure Code: T230

POD: N/A

Application: This control measure represents the application of EPA's Tier 2 motor vehicle emissions and gasoline fuel sulfur control requirements in 1999. Emissions reduction benefits of NOx, PM10-2.5, PM2.5, VOC, CO and SO2 are estimated using EPA's MOBILE6 model.

This control is applicable to all light duty vehicles beginning with the 2004 model year, and all gasoline vehicles beginning with the 1981 model year. Heavy duty diesel vehicles and motorcycles are not affected by this control.

Affected SCC:

2201001000 Light Duty Gasoline Vehicles (LDGV), Total: All Road Types
2201020000 Light Duty Gasoline Trucks 1 (LDGT1), Total: All Road Types
2201040000 Light Duty Gasoline Trucks 2 (LDGT2), Total: All Road Types
2201070000 Heavy Duty Gasoline Vehicles (HDGV), Total: All Road Types
2230001000 Light Duty Diesel Vehicles (LDDV), Total: All Road Types
2230060000 Light Duty Diesel Trucks (LDDT), Total: All Road Types

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√	√			√*	√	√		√	

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: The control efficiencies varies for each vehicle type:

LDG: PM2.5 (32-58%); PM10 (18-43%); NOx (74-92%); VOC (83-88%); SO2 (90%); CO (63-73%)

HDG: PM2.5 (38%); PM10 (34%); NOx (42%); VOC (35%); SO2 (94%); CO (10%)

LDD: PM2.5 (61-93%); PM10 (58-89%); NOx (65-98%); VOC (60-90%); SO2 (0-15%); CO (45-46%)

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: To calculate costs for the Tier 2 motor vehicle emissions standards, an estimate was made of the number of vehicles affected by the control. The number of vehicles was estimated by dividing the VMT by the average annual mileage accumulation rate for each affected vehicle type and model year. The costs for the Tier 2 motor vehicle emissions standards are estimated at \$82.43 per light duty gasoline vehicle and light duty diesel truck, \$116.66 per light duty gasoline truck 1, \$210.51 per light duty diesel truck, and \$252.90 per light duty gasoline truck 2 (EPA, 1999). All costs are in 1999 dollars.

The costs for the gasoline fuel sulfur controls were applied to all gallons of gasoline fuel used by the affected vehicles (LDGV, LDGT1, LDGT2, HDGV). Low sulfur gasoline fuel is estimated to cost an additional \$0.0193 per gallon of gasoline (EPA,

AT-A-GLANCE TABLE FOR MOBILE SOURCES

1999). All costs are in 1999 dollars.

Cost Effectiveness: The cost effectiveness of the Tier 2 motor vehicle emissions and gasoline fuel sulfur control requirements varies greatly by county and depends mostly on the number of vehicles and the year modeled. Cost effectiveness ranged from \$2,050 to \$15,228 per ton NOx reduced. The average value used in AirControlNET is \$8,542.46 per ton NOx reduced. All costs are \$1999.

Comments:

Status: Demonstrated

Last Reviewed: 2003

Additional Information:

References:

EPA, 1999: U.S. Environmental Protection Agency, "Regulatory Impact Analysis - Control of Air Pollution from New Motor Vehicles: Tier 2 Motor Vehicle Emissions Standards and Gasoline Sulfur Control Requirements," EPA420-R-99-023, December 1999.

AT-A-GLANCE TABLE FOR MOBILE SOURCES

Source Category: Highway Vehicles - Light Duty Gasoline Engines

Control Measure Name: High Enhanced Inspection and Maintenance (I/M) Program

Rule Name: Not Applicable

Pechan Measure Code: mOT3

POD: N/A

Application: This control measure represents the application of EPA's high enhanced I/M performance standards to light duty gasoline vehicles in counties that do not have this requirement implemented in 1999. Emission reduction benefits of NOx, CO, and VOC are estimated using EPA's MOBILE6 model.

This control is applicable to all light duty gasoline vehicles, motor cycles, and trucks.

Affected SCC:

2201001000 Light Duty Gasoline Vehicles (LDGV), Total: All Road Types

2201020000 Light Duty Gasoline Trucks 1 (LDGT1), Total: All Road Types

2201040000 Light Duty Gasoline Trucks 2 (LDGT2), Total: All Road Types

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*	√			√	

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: The control efficiency ranged from: NOx (0.4 to 13.4%; VOC (1.8 to 19.8%); CO (0.7 to 26.1%)

Equipment Life: Not Applicable

Rule Effectiveness: Not applicable

Penetration: Not applicable

Cost Basis: To calculate costs for high enhanced I/M, an estimate was made of the number of vehicles and amount of fuel consumed by county and vehicle type. Costs were estimated on a per-vehicle basis.

The number of vehicles was estimated by dividing the VMT by the average LDGV annual mileage accumulation rate. The costs for enhanced I/M is estimated at \$ 17.95 per vehicle inspected and \$11.43 per vehicle inspected in counties with current basic or low I/M program (Pechan 2002). All costs are \$1997.

Cost Effectiveness: The cost effectiveness of an enhanced I/M program varies greatly by county and depends mostly on the number of vehicles and the current I/M requirements for light duty vehicles in each county. Cost effectiveness for NOx ranged from \$218,369 to \$3,900 per ton. The average C-E for NOx is \$7,949 per ton of NOx reduced (median is \$6,721 per ton). All costs are \$1997.

Comments:

Status: Demonstrated

Last Reviewed: 2002

Additional Information:

References:

Pechan 2002: "AirControlINET Specifications and Methods for Mobile Source Controls" Memo prepared for Larry Sorrels of the US EPA, December 2002.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: IC Engines - Gas

Control Measure Name: L-E (Low Speed)

Rule Name: Not Applicable

Pechan Measure Code: N02211

POD: 22

Application: This control is the application of L-E (Low Speed) technology to reduce NOx emissions.

This control applies to gasoline powered IC engines with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

20200202 Industrial, Natural Gas, Reciprocating
20200204 Natural Gas, Reciprocating: Cogeneration
20300201 Natural Gas, Reciprocating
20300204 Natural Gas, Cogeneration

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 87% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Cost equations for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan-Avanti, 1998). A capital cost to annual cost ratio based upon information provided in the respective Alternative Control Techniques (ACT) document is also assigned (EPA, 1993). In cases where the default cost per ton value of 4.3 was applied, a default capital and operating and maintenance cost could also be determined. A discount rate of 7% and a capacity factor of 65% were assumed for all sources. The equipment life of 15 years is also assumed.

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 25% (Pechan, 2001).

Cost Effectiveness: The default cost effectiveness value is \$176 per ton NOx reduced from both uncontrolled and RACT baselines (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

References:

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Stationary Reciprocating Internal Combustion Engines," EPA-453/R-93-032, Research Triangle Park, NC, July 1993

AT-A-GLANCE TABLE FOR POINT SOURCES

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.8.
.EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Stationary Reciprocating Internal Combustion Engines," EPA,-453/R-93-032, Research Triangle Park, NC, July 1993

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.8.
.EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Stationary Reciprocating Internal Combustion Engines," EPA,-453/R-93-032, Research Triangle Park, NC, July 1993

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.8.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: IC Engines - Gas - Small Sources

Control Measure Name: Selective Catalytic Reduction (SCR)

Rule Name: Not Applicable

Pechan Measure Code: N02212

POD: 22

Application: This control is the selective catalytic reduction of NO_x through add-on controls. SCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NO_x) into molecular nitrogen (N₂) and water vapor (H₂O). The SCR utilizes a catalyst to increase the NO_x removal efficiency, which allows the process to occur at lower temperatures.

Applies to small (<4,000 HP) gas-fired IC engines with uncontrolled NO_x emissions greater than 10 tons per year.

Affected SCC:

20200202 Industrial, Natural Gas, Reciprocating
20200204 Natural Gas, Reciprocating: Cogeneration
20300201 Natural Gas, Reciprocating
20300204 Natural Gas, Cogeneration

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 90% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by power (Pechan, 1998).

Engines less than 4,000 horsepower were considered small engines.

Capital and annual cost information was obtained from model engine data in the Alternative Control Techniques (ACT) document (EPA, 1993). A capital cost to annual cost ratio of 1.9 is developed to estimate default capital and operating and maintenance costs. From these determinations, default cost effectiveness values were assigned. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 15 years (EPA, 1993).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 25% (Pechan, 2001).

Cost Effectiveness: The default cost effectiveness value is \$2,769 per ton NO_x reduced from both uncontrolled and RACT baselines (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

Selective Catalytic Reduction (SCR) has been widely applied to stationary source, fossil fuel-fired, combustion units for emission control since the early 1970s. SCR is typically implemented on units requiring a higher level of NO_x control than achievable by SNCR or other combustion controls (EPA, 2002).

Like SNCR, SCR is based on the chemical reduction of the NO_x molecule. The primary difference between SNCR and SCR is that SCR uses a metal-based catalyst to increase the rate of reaction (EPA, 2002). A nitrogen based reducing reagent, such as ammonia or urea, is injected into the flue gas. The reagent reacts selectively with the flue gas NO_x within a specific temperature range and in the presence of the catalyst and oxygen to reduce the NO_x.

The use of a catalyst results in two advantages of the SCR process over SNCR, the higher NO_x reduction efficiency and the lower and broader temperature ranges. However, the decrease in reaction temperature and increase in efficiency is accompanied by a significant increase in capital and operating costs (EPA, 2002). The cost increase is due to the large amount of catalyst required.

The SCR system can utilize either aqueous or anhydrous ammonia as the reagent. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Today, catalyst formulations include single component, multi-component, or active phase with a support structure. Most catalyst formulations contain additional compounds or supports, providing thermal and structural stability or to increase surface area (EPA, 2002).

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include: reaction temperature range; residence time available in the optimum temperature range; degree of mixing between the injected reagent and the combustion gases; uncontrolled NO_x concentration level; molar ratio of injected reagent to uncontrolled NO_x; ammonia slip; catalyst activity; catalyst selectivity; pressure drop across the catalyst; catalyst pitch; catalyst deactivation; and catalyst management (EPA, 2001).

References:

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Stationary Reciprocating Internal Combustion Engines," EPA-453/R-93-032, Research Triangle Park, NC, July 1993.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: IC Engines - Gas, Diesel, LPG - Small Sources

Control Measure Name: Ignition Retard

Rule Name: Not Applicable

Pechan Measure Code: N0461S, N04601

POD: 46

Application: This control is the use of ignition retard technologies to reduce NOx emissions.

This applies to small (<1 ton NOx per OSD) gas, diesel and LPG IC engines with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

20200301 Gasoline, Reciprocating

20200401 Industrial, Large Bore Engine, Diesel

20200402 Large Bore Engine, Dual Fuel (Oil/Gas)

20200403 Large Bore Engine, Cogeneration: Dual Fuel

20200902 Kerosene/Naphtha (Jet Fuel), Reciprocating

20201001 Liquefied Petroleum Gas (LPG), Propane: Reciprocating

20300301 Gasoline, Reciprocating

20301001 Liquefied Petroleum Gas (LPG), Propane: Reciprocating

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√/*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 25% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by power (Pechan, 1998).

Engines less than 4,000 horsepower were considered small engines.

Capital and annual cost information was obtained from model engine data in the Alternative Control Techniques (ACT) document (EPA, 1993). A capital cost to annual cost ratio of 1.1 was developed to estimate default capital and operating and maintenance costs. From these determinations, default cost effectiveness values were assigned. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 15 years (EPA, 1993).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 25% (Pechan, 2001).

Cost Effectiveness: The default cost effectiveness value is \$770 per ton NOx reduced from both uncontrolled RACT baselines (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

References:

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Stationary Reciprocating Internal Combustion Engines," EPA,-453/R-93-032, Research Triangle Park, NC, July 1993

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.8.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: IC Engines - Gas, Diesel, LPG - Small Sources

Control Measure Name: Selective Catalytic Reduction (SCR)

Rule Name: Not Applicable

Pechan Measure Code: N0464S, N04604

POD: 46

Application: This control is the selective catalytic reduction of NO_x through add-on controls. SCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NO_x) into molecular nitrogen (N₂) and water vapor (H₂O). The SCR utilizes a catalyst to increase the NO_x removal efficiency, which allows the process to occur at lower temperatures.

This control applies to small (<4,000 HP) gas, diesel and LPG-fired IC engines with uncontrolled NO_x emissions greater than 10 tons per year.

Affected SCC:

20200301 Gasoline, Reciprocating
20200401 Industrial, Large Bore Engine, Diesel
20200402 Large Bore Engine, Dual Fuel (Oil/Gas)
20200403 Large Bore Engine, Cogeneration: Dual Fuel
20200902 Kerosene/Naphtha (Jet Fuel), Reciprocating
20201001 Liquefied Petroleum Gas (LPG), Propane: Reciprocating
20300301 Gasoline, Reciprocating
20301001 Liquefied Petroleum Gas (LPG), Propane: Reciprocating

Pollutant(s)	PM10	PM2.5	EC	OC	NO _x	VOC	SO ₂	NH ₃	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 80% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by power (Pechan, 1998).

Engines less than 4,000 horsepower were considered small engines.

Capital and annual cost information was obtained from model engine data in the Alternative Control Techniques (ACT) document (EPA, 1993). A capital cost to annual cost ratio of 1.8 was developed to estimate default capital and operating and maintenance costs. From these determinations, default cost effectiveness values were assigned. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 15 years (EPA, 1993).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 25% (Pechan, 2001).

Cost Effectiveness: The default cost effectiveness value is \$2,340 per ton NO_x reduced from both uncontrolled and RACT baselines (1990\$).

AT-A-GLANCE TABLE FOR POINT SOURCES

Comments:**Status:** Demonstrated**Last Reviewed:** 2001

Additional Information:

Selective Catalytic Reduction (SCR) has been widely applied to stationary source, fossil fuel-fired, combustion units for emission control since the early 1970s. SCR is typically implemented on units requiring a higher level of NO_x control than achievable by SNCR or other combustion controls (EPA, 2002).

Like SNCR, SCR is based on the chemical reduction of the NO_x molecule. The primary difference between SNCR and SCR is that SCR uses a metal-based catalyst to increase the rate of reaction (EPA, 2002). A nitrogen based reducing reagent, such as ammonia or urea, is injected into the flue gas. The reagent reacts selectively with the flue gas NO_x within a specific temperature range and in the presence of the catalyst and oxygen to reduce the NO_x.

The use of a catalyst results in two advantages of the SCR process over SNCR, the higher NO_x reduction efficiency and the lower and broader temperature ranges. However, the decrease in reaction temperature and increase in efficiency is accompanied by a significant increase in capital and operating costs (EPA, 2002). The cost increase is due to the large amount of catalyst required.

The SCR system can utilize either aqueous or anhydrous ammonia as the reagent. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Today, catalyst formulations include single component, multi-component, or active phase with a support structure. Most catalyst formulations contain additional compounds or supports, providing thermal and structural stability or to increase surface area (EPA, 2002).

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include: reaction temperature range; residence time available in the optimum temperature range; degree of mixing between the injected reagent and the combustion gases; uncontrolled NO_x concentration level; molar ratio of injected reagent to uncontrolled NO_x; ammonia slip; catalyst activity; catalyst selectivity; pressure drop across the catalyst; catalyst pitch; catalyst deactivation; and catalyst management (EPA, 2001).

References:

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Stationary Reciprocating Internal Combustion Engines," EPA-453/R-93-032, Research Triangle Park, NC, July 1993.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

AT-A-GLANCE TABLE FOR POINT SOURCES

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

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AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: ICI Boilers - Coal/Cyclone - Large Sources

Control Measure Name: Coal Reburn

Rule Name: Not Applicable

Pechan Measure Code: N0142L, N01402

POD: 14

Application: This control reduces NOx emissions through coal reburn.

This control is applicable to large coal/cyclone ICI boilers classified under SCCs 10200203 and 10300223.

Affected SCC:

10200203 Industrial, Bituminous/Subbituminous Coal, Cyclone Furnace

10300223 Bituminous/Subbituminous Coal, Cyclone Furnace (Subbituminous Coal)

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 50% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NOx emission levels (Pechan, 1998).

Large source = emissions level greater than 1 ton per ozone season day

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned along with a capital to annual costs ratio of 2.0. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 20 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 70% (Pechan, 2001).

O&M Cost Components: The O&M cost component breakdown is estimated using the material in Appendix B – 4.0 Cyclone-Fired boilers for coal reburning of the Cadmus report (1995). Cost breakdowns were provided in this Group 2 boiler analysis for 150 MW and 400 MW cyclone boilers. A capacity factor of 0.65 is used in estimating the O&M cost breakdown.

Electricity cost: \$0.05/kW-hr

Coal cost: \$1.60/MMBtu

Cost Effectiveness: The default cost effectiveness values is \$300 per ton NOx reduced from both uncontrolled and RACT (1990\$).

Comments:

AT-A-GLANCE TABLE FOR POINT SOURCES

Status: Demonstrated	Last Reviewed: 2001
Additional Information:	

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Industrial/Commercial/Institutional (ICI) Boilers," EPA,-453/R-94-022, Research Triangle Park, NC, June 1994.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

Cadmus, 1995: The Cadmus Group, Inc., Investigation and Performance and Cost of NOx Controls as Applied to Group 2 Boilers, Draft Report, prepared for U.S. Environmental Protection Agency, Acid Rain Division, Washington, DC, August 1995.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: ICI Boilers - Coal/Cyclone - Small Sources

Control Measure Name: Selective Non-Catalytic Reduction (SNCR)

Rule Name: Not Applicable

Pechan Measure Code: N0141S, N01401

POD: 14

Application: This control is the reduction of NO_x emission through selective non-catalytic reduction add-on controls. SNCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NO_x) into molecular nitrogen (N₂) and water vapor (H₂O).

This control applies to small (<1 ton NO_x emissions per OSD) coal/cyclone IC boilers with uncontrolled NO_x emissions greater than 10 tons per year.

Affected SCC:

10200203 Industrial, Bituminous/Subbituminous Coal, Cyclone Furnace

10300223 Bituminous/Subbituminous Coal, Cyclone Furnace (Subbituminous Coal)

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 35% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NO_x emission levels (Pechan, 1998).

Small source = emission levels less than 1 ton per ozone season day

Costs for stationary source NO_x control are based on an analysis of EPA's NO_x State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned for small sources. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 20 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 70% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown is estimated using the example problem in the OAQPS Control Cost Manual chapter on SNCR. This example was for a 1,000 MMBtu/hr boiler burning sub-bituminous coal.

Electricity cost: \$0.05/kW-hr

Coal cost: \$1.60/MMBtu

Cost Effectiveness: The cost effectiveness used in AirControlNET for both reductions from baseline and reductions from RACT is \$840 per ton NO_x reduced (1990\$).

Comments:

AT-A-GLANCE TABLE FOR POINT SOURCES

Status: Demonstrated	Last Reviewed: 2001
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Additional Information:

SNCR is the reduction of NO_x in flue gas to N₂ and water vapor. This reduction is done with a nitrogen based reducing reagent, such as ammonia or urea. The reagent can react with a number of flue gas components. However, the NO_x reduction reaction is favored for a specific temperature range and in the presence of oxygen (EPA, 2002).

Both ammonia and urea are used as reagents. The cost of the reagent represents a large part of the annual costs of an SNCR system. Ammonia is generally less expensive than urea. However, the choice of reagent is also based on physical properties and operational considerations (EPA, 2002).

Ammonia can be utilized in either aqueous or anhydrous form. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Urea based systems have several advantages, including several safety aspects. Urea is a nontoxic, less volatile liquid that can be stored and handled more safely than ammonia. Urea solution droplets can penetrate farther into the flue gas when injected into the boiler, enhancing mixing (EPA, 2002). Because of these advantages, urea is more commonly used than ammonia in large boiler applications.

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include:

Reaction temperature range;
Residence time available in the optimum temperature range;
Degree of mixing between the injected reagent and the combustion gases
Uncontrolled NO_x concentration level;
Molar ratio of injected reagent to uncontrolled NO_x ; and ammonia slip.

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Industrial/Commercial/Institutional (ICI) Boilers," EPA-453/R-94-022, Research Triangle Park, NC, June 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: ICI Boilers - Coal/Cyclone - Small Sources

Control Measure Name: Coal Reburn

Rule Name: Not Applicable

Pechan Measure Code: N0142S

POD: 14

Application: This control reduces NOx emissions through coal reburn.

This control is applicable to small coal/cyclone ICI boilers classified under SCCs 10200203 and 10300223.

Affected SCC:

10200203 Industrial, Bituminous/Subbituminous Coal, Cyclone Furnace

10300223 Bituminous/Subbituminous Coal, Cyclone Furnace (Subbituminous Coal)

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 50% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NOx emission levels (Pechan, 1998).

Small source = emissions level less than 1 ton per ozone season day

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned along with a capital to annual costs ratio of 2.0. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 20 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 70% (Pechan, 2001).

O&M Cost Components: The O&M cost component breakdown is estimated using the material in Appendix B – 4.0 Cyclone-Fired boilers for coal reburning of the Cadmus report (1995). Cost breakdowns were provided in this Group 2 boiler analysis for 150 MW and 400 MW cyclone boilers. A capacity factor of 0.65 is used in estimating the O&M cost breakdown.

Electricity cost: \$0.05/kW-hr

Coal cost: \$1.60/MMBtu

Cost Effectiveness: The default cost effectiveness values is \$1,570 per ton NOx reduced from both uncontrolled and RACT (1990\$).

Comments:

AT-A-GLANCE TABLE FOR POINT SOURCES

Status: Demonstrated	Last Reviewed: 2001
Additional Information:	

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Industrial/Commercial/Institutional (ICI) Boilers," EPA,-453/R-94-022, Research Triangle Park, NC, June 1994.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

Cadmus, 1995: The Cadmus Group, Inc., Investigation and Performance and Cost of NOx Controls as Applied to Group 2 Boilers, Draft Report, prepared for U.S. Environmental Protection Agency, Acid Rain Division, Washington, DC, August 1995.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: ICI Boilers - Coal/Cyclone - Small Sources

Control Measure Name: Selective Catalytic Reduction (SCR)

Rule Name: Not Applicable

Pechan Measure Code: N0143S, N01403

POD: 14

Application: This control is the selective catalytic reduction of NO_x through add-on controls. SCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NO_x) into molecular nitrogen (N₂) and water vapor (H₂O). The SCR utilizes a catalyst to increase the NO_x removal efficiency, which allows the process to occur at lower temperatures.

This control applies to small (<1 ton NO_x per OSD) coal/cyclone ICI boilers with uncontrolled NO_x emissions greater than 10 tons per year.

Affected SCC:

10200203 Industrial, Bituminous/Subbituminous Coal, Cyclone Furnace

10300223 Bituminous/Subbituminous Coal, Cyclone Furnace (Subbituminous Coal)

Pollutant(s)	PM10	PM2.5	EC	OC	NO _x	VOC	SO ₂	NH ₃	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 80% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NO_x emission levels (Pechan, 1998).

Small source = emission levels less than 1 ton per ozone season day

Costs for stationary source NO_x control are based on an analysis of EPA's NO_x State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values and a capital to annual cost ratio of 7.0 are assigned. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 20 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 70% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown is estimated using the Chapter 4 costing algorithms in EPA, 2001. The fixed O&M cost is the sum of the annual maintenance material and labor cost, and is estimated to be 0.66 percent of the capital cost. This portion of the O&M cost is included in the database as maintenance labor. The NH₃ use cost equation is used to estimate chemicals costs. The annual replacement cost equation is used to estimate replacement materials costs. The energy requirement cost equation is used to estimate electricity costs.

Electricity cost = \$0.03/kW-hr

AT-A-GLANCE TABLE FOR POINT SOURCES

Ammonia cost = \$225/ton

The above O&M component costs are in 2000 dollars. The model plant size used to estimate ICI boiler O&M cost components is 400 MMBtu/hr.

Cost Effectiveness: The default cost effectiveness value is \$820 per ton NO_x reduced from both uncontrolled and RACT baselines (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

Selective Catalytic Reduction (SCR) has been widely applied to stationary source, fossil fuel-fired, combustion units for emission control since the early 1970s. SCR is typically implemented on units requiring a higher level of NO_x control than achievable by SNCR or other combustion controls (EPA, 2002).

Like SNCR, SCR is based on the chemical reduction of the NO_x molecule. The primary difference between SNCR and SCR is that SCR uses a metal-based catalyst to increase the rate of reaction (EPA, 2002). A nitrogen based reducing reagent, such as ammonia or urea, is injected into the flue gas. The reagent reacts selectively with the flue gas NO_x within a specific temperature range and in the presence of the catalyst and oxygen to reduce the NO_x.

The use of a catalyst results in two advantages of the SCR process over SNCR, the higher NO_x reduction efficiency and the lower and broader temperature ranges. However, the decrease in reaction temperature and increase in efficiency is accompanied by a significant increase in capital and operating costs (EPA, 2002). The cost increase is due to the large amount of catalyst required.

The SCR system can utilize either aqueous or anhydrous ammonia as the reagent. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Today, catalyst formulations include single component, multi-component, or active phase with a support structure. Most catalyst formulations contain additional compounds or sup-ports, providing thermal and structural stability or to increase surface area (EPA, 2002).

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include: reaction temperature range; residence time available in the optimum temperature range; degree of mixing between the injected reagent and the combustion gases; uncontrolled NO_x concentration level; molar ratio of injected reagent to uncontrolled NO_x; ammonia slip; catalyst activity; catalyst selectivity; pressure drop across the catalyst; catalyst pitch; catalyst deactivation; and catalyst management (EPA, 2001).

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Industrial/Commercial/Institutional (ICI) Boilers," EPA,-453/R-94-022, Research Triangle Park, NC, June 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards,

AT-A-GLANCE TABLE FOR POINT SOURCES

"EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: ICI Boilers - Coal/Cyclone - Small Sources

Control Measure Name: Natural Gas Reburn (NGR)

Rule Name: Not Applicable

Pechan Measure Code: N0144S, N01404

POD: 14

Application: Natural gas reburning (NGR) involves add-on controls to reduce NO_x emissions. NGR is a combustion control technology in which part of the main fuel heat input is diverted to locations above the main burners, called the reburn zone. As flue gas passes through the reburn zone, a portion of the NO_x formed in the main combustion zone is reduced by hydrocarbon radicals and converted to molecular nitrogen (N₂).

This control applies to small (<1 ton NO_x per OSD) coal/cyclone ICI boilers with uncontrolled NO_x emissions greater than 10 tons per year.

Affected SCC:

10200203 Industrial, Bituminous/Subbituminous Coal, Cyclone Furnace

10300223 Bituminous/Subbituminous Coal, Cyclone Furnace (Subbituminous Coal)

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 55% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by power output (Pechan, 1998).

Small source = less than 1 ton NO_x per ozone season day

Costs for stationary source NO_x control are based on an analysis of EPA's NO_x State Implementation Plan (SIP) Call (Pechan, 1998). The basis of the costs are model plant data in the Alternative Control Techniques (ACT) document (EPA, 1994). From this analysis, default cost per ton values are assigned along with a capital to annual costs ratio of 2.0. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 20 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 70% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown is estimated using the economic analysis for a 200 megawatt unit provided in Appendix E: Cost Analysis of Reburning Systems for conventional gas reburn. The example calculation with a \$1.00 per million Btu difference between the primary fuel cost and the reburn fuel cost was used. The reference for this information is the 1998 Andover Technology Partners report for NESCAUM/MARAMA. The fuel cost differential is the dominant operating cost of NGR.

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Coal Cost: \$1.50/MMBtu
Natural Gas Cost: \$2.50/MMBtu

Cost Effectiveness: The default cost effectiveness value is \$1,570 per ton NO_x reduced from both uncontrolled and RACT baselines (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

In a reburn boiler, fuel is injected into the upper furnace region to convert the NO_x formed in the primary combustion zone to molecular N₂ and H₂O. In general, the overall process occurs within three zones of the boiler; the combustion zone, the gas reburning zone, and the burnout zone (ERG, 2000). In the combustion zone the amount of fuel is reduced and the burners may be operated at the lowest excess air level. In the gas reburning zone the fuel not used in the combustion zone is injected to create a fuel-rich region where radicals can react with NO_x to form molecular Nitrogen. In the burnout zone a separate overfire air system redirects air from the primary combustion zone to ensure complete combustion of unreacted fuel leaving the reburning zone.

Operational parameters that affect the performance of reburn include reburn zone stoichiometry, residence time in the reburn zone, reburn fuel carrier gas and temperature and O₂ levels in the burnout zone (ERG, 2000).

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Industrial/Commercial/Institutional (ICI) Boilers," EPA-453/R-94-022, Research Triangle Park, NC, June 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

ERG, 2000: Eastern Research Group, Inc., "How to Incorporate the Effects of Air Pollution Control Device Efficiencies and Malfunctions into Emission Inventory Estimates," prepared for Emission Inventory Improvement Program, Point Sources Committee, July 2000.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

Staudt, 1998: Staudt, James E., "Status Report on NO_x Control Technologies and Cost Effectiveness for Utility Boilers," Andover Technology Partners, North Andover, MA, prepared for NESCAUM and MARAMA, June 1998.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: ICI Boilers - Coal/FBC - Large Sources

Control Measure Name: Selective Non-Catalytic Reduction (SNCR) Urea Based

Rule Name: Not Applicable

Pechan Measure Code: N0121L, N01201

POD: 12

Application: This control is the reduction of NOx emission through urea based selective non-catalytic reduction add-on controls. SNCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NOx) into molecular nitrogen (N2) and water vapor (H2O).

This control applies to large (>1 ton NOx emissions per OSD) coal-fired/fluidized bed combustion IC boilers with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

10200217 Bituminous/Subbituminous Coal, Atm. Fluidized Bed Combustion-Bubbling (Bituminous)

10300217 Commercial/Institutional, Atm. Fluidized Bed Combustion-Bubbling (Bituminous Coal)

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 40% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NOx emission levels (Pechan, 1998).

Large source = emission levels greater than 1 ton per ozone season day

Where information was available in the Alternative Control Techniques (ACT) document (EPA, 1994), capacity-based equations are used to calculate costs. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 20 years (EPA, 1994).

In general, incremental cost equations (or defaults cost) are used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 70% (Pechan, 2001).

The following equations, based primarily on information in the Air Pollution Cost Manual (EPA, 2002), are used for large NOx sources as defined above:

From Uncontrolled:

Capital Cost = 15,972.8 * Capacity (MMBtu/hr)^{0.6}

Annual Cost = 4,970.5 * Capacity (MMBtu/hr)^{0.6}

From RACT Baseline:

Capital Cost = 15,972.8 * Capacity (MMBtu/hr)^{0.6}

Annual Cost = 3,059.2 * Capacity (MMBtu/hr)^{0.6}

AT-A-GLANCE TABLE FOR POINT SOURCES

Note: All costs are in 1990 dollars.

O&M Cost Components: The O&M cost breakdown is estimated using the example problem in the OAQPS Control Cost Manual chapter on SNCR. This example was for a 1,000 MMBtu/hr boiler burning sub-bituminous coal.

Electricity cost: \$0.05/kW-hr

Coal cost: \$1.60/MMBtu

Cost Effectiveness: When capacity is available and within the applicable range of 0 to 2,000 MMBTU/hr the cost equations are used to calculate cost effectiveness. The default cost effectiveness values, used when capacity information is not available, is \$670 per ton NO_x reduced from both uncontrolled and RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

SNCR is the reduction of NO_x in flue gas to N₂ and water vapor. This reduction is done with a nitrogen based reducing reagent, such as ammonia or urea. The reagent can react with a number of flue gas components. However, the NO_x reduction reaction is favored for a specific temperature range and in the presence of oxygen (EPA, 2002).

Urea based systems have several advantages, including several safety aspects. Urea is a nontoxic, less volatile liquid that can be stored and handled more safely than ammonia. Urea solution droplets can penetrate farther into the flue gas when injected into the boiler, enhancing mixing (EPA, 2002). Because of these advantages, urea is more commonly used than ammonia in large boiler applications.

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include:

Reaction temperature range;

Residence time available in the optimum temperature range;

Degree of mixing between the injected reagent and the combustion gases

Uncontrolled NO_x concentration level;

Molar ratio of injected reagent to uncontrolled NO_x; and

Ammonia slip.

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Industrial/Commercial/Institutional (ICI) Boilers," EPA-453/R-94-022, Research Triangle Park, NC, June 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity

AT-A-GLANCE TABLE FOR POINT SOURCES

Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: ICI Boilers - Coal/FBC - Small Sources

Control Measure Name: Selective Non-Catalytic Reduction (SNCR) Urea Based

Rule Name: Not Applicable

Pechan Measure Code: N0121S

POD: 12

Application: This control is the reduction of NOx emission through urea based selective non-catalytic reduction add-on controls. SNCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NOx) into molecular nitrogen (N2) and water vapor (H2O).

This control applies to small (<1 ton NOx emissions per OSD) coal-fired/fluidized bed combustion IC boilers with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

10200217 Bituminous/Subbituminous Coal, Atm. Fluidized Bed Combustion-Bubbling (Bituminous)

10300217 Commercial/Institutional, Atm. Fluidized Bed Combustion-Bubbling (Bituminous Coal)

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 75% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NOx emission levels (Pechan, 1998).

Small source = emission levels less than 1 ton per ozone season day

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned for small sources. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 20 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 70% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown is estimated using the example problem in the OAQPS Control Cost Manual chapter on SNCR. This example was for a 1,000 MMBtu/hr boiler burning sub-bituminous coal.

Electricity cost: \$0.05/kW-hr

Coal cost: \$1.60/MMBtu

Cost Effectiveness: The cost effectiveness used in AirControlNET for both reductions from baseline and reductions from RACT is \$900 per ton NOx reduced (1990\$).

Comments:

AT-A-GLANCE TABLE FOR POINT SOURCES

Status: Demonstrated	Last Reviewed: 2001
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Additional Information:

SNCR is the reduction of NO_x in flue gas to N₂ and water vapor. This reduction is done with a nitrogen based reducing reagent, such as ammonia or urea. The reagent can react with a number of flue gas components. However, the NO_x reduction reaction is favored for a specific temperature range and in the presence of oxygen (EPA, 2002).

Urea based systems have several advantages, including several safety aspects. Urea is a nontoxic, less volatile liquid that can be stored and handled more safely than ammonia. Urea solution droplets can penetrate farther into the flue gas when injected into the boiler, enhancing mixing (EPA, 2002). Because of these advantages, urea is more commonly used than ammonia in large boiler applications.

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include:

Reaction temperature range;
Residence time available in the optimum temperature range;
Degree of mixing between the injected reagent and the combustion gases
Uncontrolled NO_x concentration level;
Molar ratio of injected reagent to uncontrolled NO_x ; and
Ammonia slip.

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Industrial/Commercial/Institutional (ICI) Boilers," EPA,-453/R-94-022, Research Triangle Park, NC, June 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: ICI Boilers - Coal/Stoker - Small Sources

Control Measure Name: Selective Non-Catalytic Reduction (SNCR)

Rule Name: Not Applicable

Pechan Measure Code: N0131L, N01301

POD: 13

Application: This control is the reduction of NO_x emission through selective non-catalytic reduction add-on controls to coal/stoker IC boilers. SNCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NO_x) into molecular nitrogen (N₂) and water vapor (H₂O).

This control applies to large (>1 ton NO_x emissions per OSD) coal/stoker IC boilers with uncontrolled NO_x emissions greater than 10 tons per year, classified under SCC 10200204.

Affected SCC:

10200204 Industrial, Bituminous/Subbituminous Coal, Spreader Stoker

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 40% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NO_x emission levels (Pechan, 1998).

Large source = emission levels greater than 1 ton per ozone season day

Where information was available in the Alternative Control Techniques (ACT) document (EPA, 1994), capacity-based equations are used to calculate costs. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 20 years (EPA, 1994).

In general, incremental cost equations (or defaults cost) are used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 70% (Pechan, 2001).

The following equations, based primarily on information in the Air Pollution Cost Manual (EPA, 2002), are used for large NO_x sources as defined above:

From Uncontrolled:

Capital Cost = 110,487.6 * Capacity (MMBtu/hr)^{0.423}

Annual Cost = 3,440.9 * Capacity (MMBtu/hr)^{0.7337}

From RACT Baseline:

AT-A-GLANCE TABLE FOR POINT SOURCES

Capital Cost = 67,093.8 * Capacity (MMBtu/hr)^{0.423}

Annual Cost = 7,514.2 * Capacity (MMBtu/hr)^{0.4195}

Note: All costs are in 1990 dollars.

O&M Cost Components: The O&M cost breakdown is estimated using the example problem in the OAQPS Control Cost Manual chapter on SNCR. This example was for a 1,000 MMBtu/hr boiler burning sub-bituminous coal.

Electricity cost: \$0.05/kW-hr

Coal cost: \$1.60/MMBtu

Cost Effectiveness: When capacity is available and within the applicable range of 0 to 2,000 MMBTU/hr the cost equations are used to calculate cost effectiveness. The default cost effectiveness value, used when capacity information is not available, is \$817 per ton NO_x reduced from uncontrolled and \$703 per ton NO_x reduced from RACT (1990\$).

Comments:

Status: Demonstrated	Last Reviewed: 2001
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Additional Information:

SNCR is the reduction of NO_x in flue gas to N₂ and water vapor. This reduction is done with a nitrogen based reducing reagent, such as ammonia or urea. The reagent can react with a number of flue gas components. However, the NO_x reduction reaction is favored for a specific temperature range and in the presence of oxygen (EPA, 2002).

Both ammonia and urea are used as reagents. The cost of the reagent represents a large part of the annual costs of an SNCR system. Ammonia is generally less expensive than urea. However, the choice of reagent is also based on physical properties and operational considerations (EPA, 2002).

Ammonia can be utilized in either aqueous or anhydrous form. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Urea based systems have several advantages, including several safety aspects. Urea is a nontoxic, less volatile liquid that can be stored and handled more safely than ammonia. Urea solution droplets can penetrate farther into the flue gas when injected into the boiler, enhancing mixing (EPA, 2002). Because of these advantages, urea is more commonly used than ammonia in large boiler applications.

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include:

Reaction temperature range;

Residence time available in the optimum temperature range;

Degree of mixing between the injected reagent and the combustion gases

Uncontrolled NO_x concentration level;

Molar ratio of injected reagent to uncontrolled NO_x ; and ammonia slip.

AT-A-GLANCE TABLE FOR POINT SOURCES

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Industrial/Commercial/Institutional (ICI) Boilers," EPA-453/R-94-022, Research Triangle Park, NC, June 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: ICI Boilers - Coal/Stoker - Small Sources

Control Measure Name: Selective Non-Catalytic Reduction (SNCR)

Rule Name: Not Applicable

Pechan Measure Code: N0131S

POD: 13

Application: This control is the reduction of NO_x emission through selective non-catalytic reduction add-on controls. SNCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NO_x) into molecular nitrogen (N₂) and water vapor (H₂O).

This control applies to small (<1 ton NO_x emissions per OSD) coal/stoker IC boilers with uncontrolled NO_x emissions greater than 10 tons per year.

Affected SCC:

10200104 Anthracite Coal, Traveling Grate (Overfeed) Stoker
10200204 Industrial, Bituminous/Subbituminous Coal, Spreader Stoker
10200205 Industrial, Bituminous/Subbituminous Coal, Overfeed Stoker
10200206 Industrial, Bituminous/Subbituminous Coal, Underfeed Stoker
10200210 Industrial, Bituminous/Subbituminous Coal, Overfeed Stoker **
10200224 Industrial, Bituminous/Subbituminous Coal, Spreader Stoker (Subbituminous Coal)
10200225 Bituminous/Subbituminous Coal, Traveling Grate (Overfeed) Stoker (Subbituminous)
10200306 Lignite, Spreader Stoker
10300102 Anthracite Coal, Traveling Grate (Overfeed) Stoker
10300207 Commercial/Institutional, Overfeed Stoker (Bituminous Coal)
10300208 Commercial/Institutional, Underfeed Stoker (Bituminous Coal)
10300209 Commercial/Institutional, Spreader Stoker (Bituminous Coal)
10300224 Bituminous/Subbituminous Coal, Spreader Stoker (Subbituminous Coal)
10300225 Bituminous/Subbituminous Coal, Traveling Grate (Overfeed) Stoker (Subbituminous)

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√/*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 40% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NO_x emission levels (Pechan, 1998).

Small source = emission levels less than 1 ton per ozone season day

Costs for stationary source NO_x control are based on an analysis of EPA's NO_x State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned for small sources. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 20 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing

AT-A-GLANCE TABLE FOR POINT SOURCES

controls (RACT baseline), with efficiencies less than or equal to 70% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown is estimated using the example problem in the OAQPS Control Cost Manual chapter on SNCR. This example was for a 1,000 MMBtu/hr boiler burning sub-bituminous coal.

Electricity cost: \$0.05/kW-hr

Coal cost: \$1.60/MMBtu

Cost Effectiveness: The cost effectiveness values used in AirControlNET are \$1,015 per ton NO_x reduced from uncontrolled and \$873 per ton NO_x reduced from RACT baseline (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

SNCR is the reduction of NO_x in flue gas to N₂ and water vapor. This reduction is done with a nitrogen based reducing reagent, such as ammonia or urea. The reagent can react with a number of flue gas components. However, the NO_x reduction reaction is favored for a specific temperature range and in the presence of oxygen (EPA, 2002).

Both ammonia and urea are used as reagents. The cost of the reagent represents a large part of the annual costs of an SNCR system. Ammonia is generally less expensive than urea. However, the choice of reagent is also based on physical properties and operational considerations (EPA, 2002).

Ammonia can be utilized in either aqueous or anhydrous form. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Urea based systems have several advantages, including several safety aspects. Urea is a nontoxic, less volatile liquid that can be stored and handled more safely than ammonia. Urea solution droplets can penetrate farther into the flue gas when injected into the boiler, enhancing mixing (EPA, 2002). Because of these advantages, urea is more commonly used than ammonia in large boiler applications.

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include:

Reaction temperature range;

Residence time available in the optimum temperature range;

Degree of mixing between the injected reagent and the combustion gases

Uncontrolled NO_x concentration level;

Molar ratio of injected reagent to uncontrolled NO_x ; and ammonia slip.

References:

EEPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Industrial/Commercial/Institutional (ICI) Boilers," EPA,-453/R-94-022, Research Triangle Park, NC, June 1994.

AT-A-GLANCE TABLE FOR POINT SOURCES

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: ICI Boilers - Coal/Wall - Large Sources

Control Measure Name: Selective Non-Catalytic Reduction (SNCR)

Rule Name: Not Applicable

Pechan Measure Code: N0111L, N01101

POD: 11

Application: This control is the reduction of NOx emission through selective non-catalytic reduction add-on controls to wall fired (coal) IC boilers. SNCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NOx) into molecular nitrogen (N2) and water vapor (H2O).

This control applies to large (>1 ton NOx emissions per OSD) coal-fired IC boilers with uncontrolled NOx emissions greater than 10 tons per year, classified under SCCs 10200201 and 10200202.

Affected SCC:

10200201 Industrial, Bituminous/Subbituminous Coal, Pulverized Coal: Wet Bottom

10200202 Industrial, Bituminous/Subbituminous Coal, Pulverized Coal: Dry Bottom

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 40% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NOx emission levels (Pechan, 1998).

Large source = emission levels greater than 1 ton per ozone season day

Where information was available in the Alternative Control Techniques (ACT) document (EPA, 1994), capacity-based equations are used to calculate costs. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 20 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 70% (Pechan, 2001).

The following equations, based primarily on information in the Air Pollution Cost Manual (EPA, 2002), are used for large NOx sources as defined above:

From Uncontrolled:

Capital Cost = 110,487.6 * Capacity (MMBtu/hr)^{0.423}

Annual Cost = 3,440.9 * Capacity (MMBtu/hr)^{0.7337}

From RACT Baseline:

AT-A-GLANCE TABLE FOR POINT SOURCES

Capital Cost = $67,093.8 * \text{Capacity (MMBtu/hr)}^{0.423}$
Annual Cost = $7,514.2 * \text{Capacity (MMBtu/hr)}^{0.4195}$

Note: All costs are in 1990 dollars.

O&M Cost Components: The O&M cost breakdown is estimated using the example problem in the OAQPS Control Cost Manual chapter on SNCR. This example was for a 1,000 MMBtu/hr boiler burning sub-bituminous coal.

Electricity cost: \$0.05/kW-hr
Coal cost: \$1.60/MMBtu

Cost Effectiveness: When capacity is available and within the applicable range of 0 to 2,000 MMBTU/hr the cost equations are used to calculate cost effectiveness. The default cost effectiveness value, used when capacity information is not available, is \$840 per ton NOx reduced from uncontrolled and \$260 per ton NOx reduced from RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

SNCR is the reduction of NOx in flue gas to N2 and water vapor. This reduction is done with a nitrogen based reducing reagent, such as ammonia or urea. The reagent can react with a number of flue gas components. However, the NOx reduction reaction is favored for a specific temperature range and in the presence of oxygen (EPA, 2002).

Both ammonia and urea are used as reagents. The cost of the reagent represents a large part of the annual costs of an SNCR system. Ammonia is generally less expensive than urea. However, the choice of reagent is also based on physical properties and operational considerations (EPA, 2002).

Ammonia can be utilized in either aqueous or anhydrous form. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Urea based systems have several advantages, including several safety aspects. Urea is a nontoxic, less volatile liquid that can be stored and handled more safely than ammonia. Urea solution droplets can penetrate farther into the flue gas when injected into the boiler, enhancing mixing (EPA, 2002). Because of these advantages, urea is more commonly used than ammonia in large boiler applications.

The rate of reaction determines the amount of NOx removed from the flue gas. The important design and operational factors that affect the rate of reduction include:

Reaction temperature range;
Residence time available in the optimum temperature range;
Degree of mixing between the injected reagent and the combustion gases
Uncontrolled NOx concentration level;
Molar ratio of injected reagent to uncontrolled NOx ; and
Ammonia slip.

AT-A-GLANCE TABLE FOR POINT SOURCES

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Industrial/Commercial/Institutional (ICI) Boilers," EPA-453/R-94-022, Research Triangle Park, NC, June 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: ICI Boilers - Coal/Wall - Large Sources

Control Measure Name: Low NOx Burner

Rule Name: Not Applicable

Pechan Measure Code: N0113L, N01103

POD: 11

Application: This control is the use of low NOx burner (LNB) technology to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another.

This control is applicable to large (>1 ton NOx per OSD) coal/wall fired ICI boilers classified under SCCs 10200201 and 10200202 with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

10200201 Industrial, Bituminous/Subbituminous Coal, Pulverized Coal: Wet Bottom

10200202 Industrial, Bituminous/Subbituminous Coal, Pulverized Coal: Dry Bottom

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 50% from uncontrolled

Equipment Life: 10 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NOx emission levels (Pechan, 1998).

Large source = emission levels greater than 1 ton per ozone season day

Where information was available in the Alternative Control Techniques (ACT) document (EPA, 1994), capacity-based equations are used to calculate costs. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 10 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 70% (Pechan, 2001).

The following equations, based primarily on information in the Air Pollution Cost Manual (EPA, 2002), are used for large NOx sources as defined above:

From Uncontrolled:

Capital Cost = 53,868.7 * Capacity (MMBtu/hr)^{0.6}

Annual Cost = 11,861.1 * Capacity (MMBtu/hr)^{0.6}

From RACT Baseline:

AT-A-GLANCE TABLE FOR POINT SOURCES

Capital Cost = $53,868.7 * \text{Capacity (MMBtu/hr)}^{0.6}$
Annual Cost = $11,861.1 * \text{Capacity (MMBtu/hr)}^{0.6}$

O&M Cost Components: The O&M cost breakdown is estimated using the detailed information in Appendix F of the ACT document (see page F-4). The model boiler size used to develop O&M cost components is 766 MMBtu/hr. A capacity factor of 0.58 is used in estimating the O&M cost breakdown.

Electricity cost: \$0.05/kW-hr

Note: All costs are in 1990 dollars.

Cost Effectiveness: When capacity is available and within the applicable range of 0 to 2,000 MMBTU/hr the cost equations are used to calculate cost effectiveness. The default cost effectiveness value, used when capacity information is not available, is \$1,090 per ton NO_x reduced from both uncontrolled and RACT baselines (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNBs create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNBs create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Industrial/Commercial/Institutional (ICI) Boilers," EPA-453/R-94-022, Research Triangle Park, NC, June 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: ICI Boilers - Coal/Wall - Large Sources

Control Measure Name: Selective Catalytic Reduction (SCR)

Rule Name: Not Applicable

Pechan Measure Code: N0114L, N01104

POD: 11

Application: This control is the selective catalytic reduction of NOx through add-on controls. SCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NOx) into molecular nitrogen (N2) and water vapor (H2O). The SCR utilizes a catalyst to increase the NOx removal efficiency, which allows the process to occur at lower temperatures.

This control applies to large (>1 ton NOx emissions per OSD) coal/wall IC boilers with uncontrolled NOx emissions greater than 10 tons per year, classified under SCCs 10200201 and 10200202.

Affected SCC:

10200201 Industrial, Bituminous/Subbituminous Coal, Pulverized Coal: Wet Bottom

10200202 Industrial, Bituminous/Subbituminous Coal, Pulverized Coal: Dry Bottom

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 70% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NOx emission levels (Pechan, 1998).

Large source = emission levels greater than 1 ton per ozone season day

Where information was available in the Alternative Control Techniques (ACT) document (EPA, 1994), capacity-based equations are used to calculate costs. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 20 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 70% (Pechan, 2001).

The following equations, based primarily on information in the Air Pollution Cost Manual (EPA, 2002), are used for large NOx sources as defined above:

From Uncontrolled:

Capital Cost = 82,400.9 * Capacity (MMBtu/hr)^{0.65}

Annual Cost = 5,555.6 * Capacity (MMBtu/hr)^{0.7885}

From RACT Baseline:

AT-A-GLANCE TABLE FOR POINT SOURCES

Capital Cost = $79,002.2 * \text{Capacity (MMBtu/hr)}^{0.65}$
Annual Cost = $8,701.5 * \text{Capacity (MMBtu/hr)}^{0.6493}$

Note: All costs are in 1990 dollars.

O&M Cost Components: The O&M cost breakdown is estimated using the Chapter 4 costing algorithms in EPA, 2001. The fixed O&M cost is the sum of the annual maintenance material and labor cost, and is estimated to be 0.66 percent of the capital cost. This portion of the O&M cost is included in the database as maintenance labor. The NH₃ use cost equation is used to estimate chemicals costs. The annual replacement cost equation is used to estimate replacement materials costs. The energy requirement cost equation is used to estimate electricity costs.

Electricity cost = \$0.03/kW-hr
Ammonia cost = \$225/ton

The above O&M component costs are in 2000 dollars. The model plant size used to estimate ICI boiler O&M cost components is 400 MMBtu/hr.

Cost Effectiveness: When capacity is available and within the applicable range of 0 to 2,000 MMBTU/hr the cost equations are used to calculate cost effectiveness. The default cost effectiveness values, used when capacity information is not available, are \$1,070 per ton NO_x reduced from uncontrolled and \$700 per ton NO_x reduced from RACT (1990\$).

Comments:

Status: Demonstrated	Last Reviewed: 2001
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Additional Information:

Selective Catalytic Reduction (SCR) has been widely applied to stationary source, fossil fuel-fired, combustion units for emission control since the early 1970s. SCR is typically implemented on units requiring a higher level of NO_x control than achievable by SNCR or other combustion controls (EPA, 2002).

Like SNCR, SCR is based on the chemical reduction of the NO_x molecule. The primary difference between SNCR and SCR is that SCR uses a metal-based catalyst to increase the rate of reaction (EPA, 2002). A nitrogen based reducing reagent, such as ammonia or urea, is injected into the flue gas. The reagent reacts selectively with the flue gas NO_x within a specific temperature range and in the presence of the catalyst and oxygen to reduce the NO_x.

The use of a catalyst results in two advantages of the SCR process over SNCR, the higher NO_x reduction efficiency and the lower and broader temperature ranges. However, the decrease in reaction temperature and increase in efficiency is accompanied by a significant increase in capital and operating costs (EPA, 2002). The cost increase is due to the large amount of catalyst required.

The SCR system can utilize either aqueous or anhydrous ammonia as the reagent. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

AT-A-GLANCE TABLE FOR POINT SOURCES

Today, catalyst formulations include single component, multi-component, or active phase with a support structure. Most catalyst formulations contain additional compounds or supports, providing thermal and structural stability or to increase surface area (EPA, 2002).

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include: reaction temperature range; residence time available in the optimum temperature range; degree of mixing between the injected reagent and the combustion gases; uncontrolled NO_x concentration level; molar ratio of injected reagent to uncontrolled NO_x; ammonia slip; catalyst activity; catalyst selectivity; pressure drop across the catalyst; catalyst pitch; catalyst deactivation; and catalyst management (EPA, 2001).

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Industrial/Commercial/Institutional (ICI) Boilers," EPA-453/R-94-022, Research Triangle Park, NC, June 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: ICI Boilers - Coal/Wall - Small Sources

Control Measure Name: Selective Non-Catalytic Reduction (SNCR)

Rule Name: Not Applicable

Pechan Measure Code: N0111S

POD: 11

Application: This control is the reduction of NO_x emission through selective non-catalytic reduction add-on controls to wall fired (coal) IC boilers. SNCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NO_x) into molecular nitrogen (N₂) and water vapor (H₂O).

This control applies to small (<1 ton NO_x emissions per OSD) coal-fired IC boilers with uncontrolled NO_x emissions greater than 10 tons per year.

Affected SCC:

10200101 Anthracite Coal, Pulverized Coal
10200201 Industrial, Bituminous/Subbituminous Coal, Pulverized Coal: Wet Bottom
10200202 Industrial, Bituminous/Subbituminous Coal, Pulverized Coal: Dry Bottom
10200212 Bituminous/Subbituminous Coal, Pulverized Coal: Dry Bottom (Tangential)
10200219 Bituminous/Subbituminous Coal, Cogeneration (Bituminous Coal)
10200222 Bituminous/Subbituminous Coal, Pulverized Coal: Dry Bottom (Subbituminous Coal)
10200301 Lignite, Pulverized Coal: Dry Bottom, Wall Fired
10300101 Anthracite Coal, Pulverized Coal
10300205 Bituminous/Subbituminous Coal, Pulverized Coal: Wet Bottom (Bituminous Coal)
10300206 Commercial/Institutional, Pulverized Coal-Dry Bottom (Bituminous Coal)
10300222 Bituminous/Subbituminous Coal, Pulverized Coal: Dry Bottom (Subbituminous Coal)

Pollutant(s)	PM10	PM2.5	EC	OC	NO _x	VOC	SO ₂	NH ₃	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 40% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NO_x emission levels (Pechan, 1998).

Small source = emission levels less than 1 ton per ozone season day

Costs for stationary source NO_x control are based on an analysis of EPA's NO_x State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned for small sources. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 20 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 70% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown is estimated using the example

AT-A-GLANCE TABLE FOR POINT SOURCES

problem in the OAQPS Control Cost Manual chapter on SNCR. This example was for a 1,000 MMBtu/hr boiler burning sub-bituminous coal.

Electricity cost: \$0.05/kW-hr

Coal cost: \$1.60/MMBtu

Cost Effectiveness: The cost effectiveness values used in AirControlNET are \$1,040 per ton NO_x reduced from uncontrolled and \$400 per ton NO_x reduced from RACT baseline (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

SNCR is the reduction of NO_x in flue gas to N₂ and water vapor. This reduction is done with a nitrogen based reducing reagent, such as ammonia or urea. The reagent can react with a number of flue gas components. However, the NO_x reduction reaction is favored for a specific temperature range and in the presence of oxygen (EPA, 2002).

Both ammonia and urea are used as reagents. The cost of the reagent represents a large part of the annual costs of an SNCR system. Ammonia is generally less expensive than urea. However, the choice of reagent is also based on physical properties and operational considerations (EPA, 2002).

Ammonia can be utilized in either aqueous or anhydrous form. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Urea based systems have several advantages, including several safety aspects. Urea is a nontoxic, less volatile liquid that can be stored and handled more safely than ammonia. Urea solution droplets can penetrate farther into the flue gas when injected into the boiler, enhancing mixing (EPA, 2002). Because of these advantages, urea is more commonly used than ammonia in large boiler applications.

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include:

Reaction temperature range;

Residence time available in the optimum temperature range;

Degree of mixing between the injected reagent and the combustion gases

Uncontrolled NO_x concentration level;

Molar ratio of injected reagent to uncontrolled NO_x ; and

Ammonia slip.

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Industrial/Commercial/Institutional (ICI) Boilers," EPA-453/R-94-022, Research Triangle Park, NC, June 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC,

AT-A-GLANCE TABLE FOR POINT SOURCES

January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: ICI Boilers - Coal/Wall - Small Sources

Control Measure Name: Low NOx Burner

Rule Name: Not Applicable

Pechan Measure Code: N0113S

POD: 11

Application: This control is the use of low NOx burner (LNB) technology to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another.

This control is applicable to small (<1 ton NOx per OSD) coal/wall fired ICI boilers with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

10200101 Anthracite Coal, Pulverized Coal
10200201 Industrial, Bituminous/Subbituminous Coal, Pulverized Coal: Wet Bottom
10200202 Industrial, Bituminous/Subbituminous Coal, Pulverized Coal: Dry Bottom
10200212 Bituminous/Subbituminous Coal, Pulverized Coal: Dry Bottom (Tangential)
10200219 Bituminous/Subbituminous Coal, Cogeneration (Bituminous Coal)
10200222 Bituminous/Subbituminous Coal, Pulverized Coal: Dry Bottom (Subbituminous Coal)
10200301 Lignite, Pulverized Coal: Dry Bottom, Wall Fired
10300101 Anthracite Coal, Pulverized Coal
10300205 Bituminous/Subbituminous Coal, Pulverized Coal: Wet Bottom (Bituminous Coal)
10300206 Commercial/Institutional, Pulverized Coal-Dry Bottom (Bituminous Coal)
10300222 Bituminous/Subbituminous Coal, Pulverized Coal: Dry Bottom (Subbituminous Coal)

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 50% from uncontrolled

Equipment Life: 10 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NOx emission levels (Pechan, 1998).

Small source = emissions level less than 1 ton per ozone season day

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned along with a capital to annual costs ratio of 4.5. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 10 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 70% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown is estimated using the detailed

AT-A-GLANCE TABLE FOR POINT SOURCES

information in Appendix F of the ACT document (see page F-4). The model boiler size used to develop O&M cost components is 766 MMBtu/hr. A capacity factor of 0.58 is used in estimating the O&M cost breakdown.

Electricity cost: \$0.05/kW-hr

Cost Effectiveness: The default cost effectiveness value used in AirControlNET is \$1,460 per ton NO_x reduced from both uncontrolled and RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

LNBS are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNBS create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNBS create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Industrial/Commercial/Institutional (ICI) Boilers," EPA,-453/R-94-022, Research Triangle Park, NC, June 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: ICI Boilers - Coal/Wall - Small Sources

Control Measure Name: Selective Catalytic Reduction (SCR)

Rule Name: Not Applicable

Pechan Measure Code: N0114S

POD: 11

Application: This control is the selective catalytic reduction of NOx through add-on controls. SCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NOx) into molecular nitrogen (N₂) and water vapor (H₂O). The SCR utilizes a catalyst to increase the NOx removal efficiency, which allows the process to occur at lower temperatures.

This control applies to small (<1 ton NOx per OSD) coal/wall-fired ICI boilers with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

10200101 Anthracite Coal, Pulverized Coal
10200201 Industrial, Bituminous/Subbituminous Coal, Pulverized Coal: Wet Bottom
10200202 Industrial, Bituminous/Subbituminous Coal, Pulverized Coal: Dry Bottom
10200212 Bituminous/Subbituminous Coal, Pulverized Coal: Dry Bottom (Tangential)
10200219 Bituminous/Subbituminous Coal, Cogeneration (Bituminous Coal)
10200222 Bituminous/Subbituminous Coal, Pulverized Coal: Dry Bottom (Subbituminous Coal)
10200301 Lignite, Pulverized Coal: Dry Bottom, Wall Fired
10300101 Anthracite Coal, Pulverized Coal
10300205 Bituminous/Subbituminous Coal, Pulverized Coal: Wet Bottom (Bituminous Coal)
10300206 Commercial/Institutional, Pulverized Coal-Dry Bottom (Bituminous Coal)
10300222 Bituminous/Subbituminous Coal, Pulverized Coal: Dry Bottom (Subbituminous Coal)

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 70% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NOx emission levels (Pechan, 1998).

Small source = emission levels less than 1 ton per ozone season day

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values and a capital to annual cost ratio of 7.1 are assigned. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 20 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 70% (Pechan, 2001).

AT-A-GLANCE TABLE FOR POINT SOURCES

Cost Effectiveness: The default cost effectiveness value is \$1,260 per ton NO_x reduced from both uncontrolled and RACT baselines (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

Selective Catalytic Reduction (SCR) has been widely applied to stationary source, fossil fuel-fired, combustion units for emission control since the early 1970s. SCR is typically implemented on units requiring a higher level of NO_x control than achievable by SNCR or other combustion controls (EPA, 2002).

Like SNCR, SCR is based on the chemical reduction of the NO_x molecule. The primary difference between SNCR and SCR is that SCR uses a metal-based catalyst to increase the rate of reaction (EPA, 2002). A nitrogen based reducing reagent, such as ammonia or urea, is injected into the flue gas. The reagent reacts selectively with the flue gas NO_x within a specific temperature range and in the presence of the catalyst and oxygen to reduce the NO_x.

The use of a catalyst results in two advantages of the SCR process over SNCR, the higher NO_x reduction efficiency and the lower and broader temperature ranges. However, the decrease in reaction temperature and increase in efficiency is accompanied by a significant increase in capital and operating costs (EPA, 2002). The cost increase is due to the large amount of catalyst required.

The SCR system can utilize either aqueous or anhydrous ammonia as the reagent. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Today, catalyst formulations include single component, multi-component, or active phase with a support structure. Most catalyst formulations contain additional compounds or supports, providing thermal and structural stability or to increase surface area (EPA, 2002).

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include: reaction temperature range; residence time available in the optimum temperature range; degree of mixing between the injected reagent and the combustion gases; uncontrolled NO_x concentration level; molar ratio of injected reagent to uncontrolled NO_x; ammonia slip; catalyst activity; catalyst selectivity; pressure drop across the catalyst; catalyst pitch; catalyst deactivation; and catalyst management (EPA, 2001).

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Industrial/Commercial/Institutional (ICI) Boilers," EPA-453/R-94-022, Research Triangle Park, NC, June 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air

AT-A-GLANCE TABLE FOR POINT SOURCES

Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: ICI Boilers - Coke - Small Sources

Control Measure Name: Selective Non-Catalytic Reduction (SNCR)

Rule Name: Not Applicable

Pechan Measure Code: N0421S, N04201

POD: 42

Application: This control is the reduction of NO_x emission through selective non-catalytic reduction add-on controls. SNCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NO_x) into molecular nitrogen (N₂) and water vapor (H₂O).

This control applies to small (<1 ton NO_x emissions per OSD) coke IC boilers with uncontrolled NO_x emissions greater than 10 tons per year, classified under SCCs 10200801, 10200802, and 10200804.

Affected SCC:

10200801 Industrial, Coke

10200802 Coke, All Boiler Sizes

10200804 Coke, Cogeneration

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 40% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NO_x emission levels (Pechan, 1998).

Small source = emission levels less than 1 ton per ozone season day

Costs for stationary source NO_x control are based on an analysis of EPA's NO_x State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned for small sources. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 20 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 70% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown is estimated using the example problem in the OAQPS Control Cost Manual chapter on SNCR. This example was for a 1,000 MMBtu/hr boiler burning sub-bituminous coal.

Electricity cost: \$0.05/kW-hr

Coal cost: \$1.60/MMBtu

Cost Effectiveness: The cost effectiveness values used in AirControlNET are \$1,040 per ton NO_x

AT-A-GLANCE TABLE FOR POINT SOURCES

reduced from uncontrolled and \$400 per ton NO_x reduced from RACT baseline (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

SNCR is the reduction of NO_x in flue gas to N₂ and water vapor. This reduction is done with a nitrogen based reducing reagent, such as ammonia or urea. The reagent can react with a number of flue gas components. However, the NO_x reduction reaction is favored for a specific temperature range and in the presence of oxygen (EPA, 2002).

Both ammonia and urea are used as reagents. The cost of the reagent represents a large part of the annual costs of an SNCR system. Ammonia is generally less expensive than urea. However, the choice of reagent is also based on physical properties and operational considerations (EPA, 2002).

Ammonia can be utilized in either aqueous or anhydrous form. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Urea based systems have several advantages, including several safety aspects. Urea is a nontoxic, less volatile liquid that can be stored and handled more safely than ammonia. Urea solution droplets can penetrate farther into the flue gas when injected into the boiler, enhancing mixing (EPA, 2002). Because of these advantages, urea is more commonly used than ammonia in large boiler applications.

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include:

Reaction temperature range;
Residence time available in the optimum temperature range;
Degree of mixing between the injected reagent and the combustion gases
Uncontrolled NO_x concentration level;
Molar ratio of injected reagent to uncontrolled NO_x ; and
Ammonia slip.

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Industrial/Commercial/Institutional (ICI) Boilers," EPA,-453/R-94-022, Research Triangle Park, NC, June 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

AT-A-GLANCE TABLE FOR POINT SOURCES

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: ICI Boilers - Coke - Small Sources

Control Measure Name: Low NOx Burner

Rule Name: Not Applicable

Pechan Measure Code: N0423S, N04203

POD: 42

Application: This control is the use of low NOx burner (LNB) technology to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another.

This control is applicable to small (<1 ton NOx per OSD) coke ICI boilers with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

10200801 Industrial, Coke

10200802 Coke, All Boiler Sizes

10200804 Coke, Cogeneration

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 50% from uncontrolled

Equipment Life: 10 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NOx emission levels (Pechan, 1998).

Small source = emissions level less than 1 ton per ozone season day

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned along with a capital to annual costs ratio of 4.5. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 10 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 70% (Pechan, 2001).

Cost Effectiveness: The default cost effectiveness value used in AirControlNET is \$1,460 per ton NOx reduced from both uncontrolled and RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNBs create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNBs create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Industrial/Commercial/Institutional (ICI) Boilers," EPA,-453/R-94-022, Research Triangle Park, NC, June 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: ICI Boilers - Coke - Small Sources

Control Measure Name: Selective Catalytic Reduction (SCR)

Rule Name: Not Applicable

Pechan Measure Code: N0424S, N04204

POD: 42

Application: This control is the selective catalytic reduction of NO_x through add-on controls. SCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NO_x) into molecular nitrogen (N₂) and water vapor (H₂O). The SCR utilizes a catalyst to increase the NO_x removal efficiency, which allows the process to occur at lower temperatures.

Applies to small (<1 ton NO_x per OSD) coke ICI boilers with NO_x emissions greater than 10 tons per year.

Affected SCC:

10200801 Industrial, Coke

10200802 Coke, All Boiler Sizes

10200804 Coke, Cogeneration

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 70% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NO_x emission levels (Pechan, 1998).

Small source = emission levels less than 1 ton per ozone season day

Costs for stationary source NO_x control are based on an analysis of EPA's NO_x State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 20 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 70% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown is estimated using the Chapter 4 costing algorithms in EPA, 2001. The fixed O&M cost is the sum of the annual maintenance material and labor cost, and is estimated to be 0.66 percent of the capital cost. This portion of the O&M cost is included in the database as maintenance labor. The NH₃ use cost equation is used to estimate chemicals costs. The annual replacement cost equation is used to estimate replacement materials costs. The energy requirement cost equation is used to estimate electricity costs.

Electricity cost = \$0.03/kW-hr

AT-A-GLANCE TABLE FOR POINT SOURCES

Ammonia cost = \$225/ton

The above O&M component costs are in 2000 dollars. The model plant size used to estimate ICI boiler O&M cost components is 400 MMBtu/hr.

Cost Effectiveness: The cost effectiveness value used in AirControlNET is \$1,260 per ton NO_x reduced from uncontrolled and \$910 per ton NO_x reduced from RACT baseline (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

Selective Catalytic Reduction (SCR) has been widely applied to stationary source, fossil fuel-fired, combustion units for emission control since the early 1970s. SCR is typically implemented on units requiring a higher level of NO_x control than achievable by SNCR or other combustion controls (EPA, 2002).

Like SNCR, SCR is based on the chemical reduction of the NO_x molecule. The primary difference between SNCR and SCR is that SCR uses a metal-based catalyst to increase the rate of reaction (EPA, 2002). A nitrogen based reducing reagent, such as ammonia or urea, is injected into the flue gas. The reagent reacts selectively with the flue gas NO_x within a specific temperature range and in the presence of the catalyst and oxygen to reduce the NO_x.

The use of a catalyst results in two advantages of the SCR process over SNCR, the higher NO_x reduction efficiency and the lower and broader temperature ranges. However, the decrease in reaction temperature and increase in efficiency is accompanied by a significant increase in capital and operating costs (EPA, 2002). The cost increase is due to the large amount of catalyst required.

The SCR system can utilize either aqueous or anhydrous ammonia as the reagent. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Today, catalyst formulations include single component, multi-component, or active phase with a support structure. Most catalyst formulations contain additional compounds or supports, providing thermal and structural stability or to increase surface area (EPA, 2002).

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include: reaction temperature range; residence time available in the optimum temperature range; degree of mixing between the injected reagent and the combustion gases; uncontrolled NO_x concentration level; molar ratio of injected reagent to uncontrolled NO_x; ammonia slip; catalyst activity; catalyst selectivity; pressure drop across the catalyst; catalyst pitch; catalyst deactivation; and catalyst management (EPA, 2001).

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Industrial/Commercial/Institutional (ICI) Boilers," EPA-453/R-94-022, Research Triangle Park, NC, June 1994.

AT-A-GLANCE TABLE FOR POINT SOURCES

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: ICI Boilers - Distillate Oil - Large Sources

Control Measure Name: Selective Non-Catalytic Reduction (SNCR)

Rule Name: Not Applicable

Pechan Measure Code: N0454L, N04504

POD: 16

Application: This control is the reduction of NO_x emission through selective non-catalytic reduction add-on controls. SNCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NO_x) into molecular nitrogen (N₂) and water vapor (H₂O).

This control applies to large (>1 ton NO_x emissions per OSD) distillate oil IC boilers with uncontrolled NO_x emissions greater than 10 tons per year.

Affected SCC:

10200501 Industrial, Distillate Oil, Grades 1 and 2 Oil
10200502 Distillate Oil, 10-100 Million Btu/hr **
10200503 Distillate Oil, < 10 Million Btu/hr **
10200504 Industrial, Distillate Oil, Grade 4 Oil
10300501 Commercial/Institutional, Distillate Oil, Grades 1 and 2 Oil
10300502 Commercial/Institutional, Distillate Oil, 10-100 Million Btu/hr **
10300503 Commercial/Institutional, Distillate Oil, < 10 Million Btu/hr **
10300504 Commercial/Institutional, Distillate Oil, Grade 4 Oil

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 50% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NO_x emission levels (Pechan, 1998).

Large source = emission levels greater than 1 ton per ozone season day

Where information was available in the Alternative Control Techniques (ACT) document (EPA, 1994), capacity-based equations are used to calculate costs. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 20 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 70% (Pechan, 2001).

The following equations, based primarily on information in the Air Pollution Cost Manual (EPA, 2002), are used for large NO_x sources as defined above:

From Uncontrolled:

AT-A-GLANCE TABLE FOR POINT SOURCES

Capital Cost = 62,148.8 * Capacity (MMBtu/hr)^{0.423}
Annual Cost = 2,012.4 * Capacity (MMBtu/hr)^{0.7229}

From RACT Baseline:

Capital Cost = 48,002.6 * Capacity (MMBtu/hr)^{0.423}
Annual Cost = 5,244.4 * Capacity (MMBtu/hr)^{0.4238}

Note: All costs are in 1990 dollars.

O&M Cost Components: The O&M cost breakdown is estimated using the example problem in the OAQPS Control Cost Manual chapter on SNCR. This example was for a 1,000 MMBtu/hr boiler burning sub-bituminous coal.

Electricity cost: \$0.05/kW-hr
Coal cost: \$1.60/MMBtu

Cost Effectiveness: When capacity is available and within the applicable range of 0 to 2,000 MMBTU/hr the cost equations are used to calculate cost effectiveness. The default cost effectiveness value, used when capacity information is not available, is \$1,890 per ton NO_x reduced from uncontrolled and \$1,010 per ton NO_x reduced from RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

SNCR is the reduction of NO_x in flue gas to N₂ and water vapor. This reduction is done with a nitrogen based reducing reagent, such as ammonia or urea. The reagent can react with a number of flue gas components. However, the NO_x reduction reaction is favored for a specific temperature range and in the presence of oxygen (EPA, 2002).

Both ammonia and urea are used as reagents. The cost of the reagent represents a large part of the annual costs of an SNCR system. Ammonia is generally less expensive than urea. However, the choice of reagent is also based on physical properties and operational considerations (EPA, 2002).

Ammonia can be utilized in either aqueous or anhydrous form. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Urea based systems have several advantages, including several safety aspects. Urea is a nontoxic, less volatile liquid that can be stored and handled more safely than ammonia. Urea solution droplets can penetrate farther into the flue gas when injected into the boiler, enhancing mixing (EPA, 2002). Because of these advantages, urea is more commonly used than ammonia in large boiler applications.

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include:

Reaction temperature range;
Residence time available in the optimum temperature range;

AT-A-GLANCE TABLE FOR POINT SOURCES

Degree of mixing between the injected reagent and the combustion gases
Uncontrolled NO_x concentration level;
Molar ratio of injected reagent to uncontrolled NO_x ; and
Ammonia slip.

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Industrial/Commercial/Institutional (ICI) Boilers," EPA,-453/R-94-022, Research Triangle Park, NC, June 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: ICI Boilers - Distillate Oil - Small Sources

Control Measure Name: Low NOx Burner

Rule Name: Not Applicable

Pechan Measure Code: N0161S, N01601

POD: 16

Application: This control is the use of low NOx burner (LNB) technology to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another.

This control is applicable to distillate oil-fired ICI boilers with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

10200501 Industrial, Distillate Oil, Grades 1 and 2 Oil
10200502 Distillate Oil, 10-100 Million Btu/hr **
10200503 Distillate Oil, < 10 Million Btu/hr **
10200504 Industrial, Distillate Oil, Grade 4 Oil
10300501 Commercial/Institutional, Distillate Oil, Grades 1 and 2 Oil
10300502 Commercial/Institutional, Distillate Oil, 10-100 Million Btu/hr **
10300503 Commercial/Institutional, Distillate Oil, < 10 Million Btu/hr **
10300504 Commercial/Institutional, Distillate Oil, Grade 4 Oil

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 50% from uncontrolled

Equipment Life: 10 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NOx emission levels (Pechan, 1998).

Small source = emissions level less than 1 ton per ozone season day

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned along with a capital to annual costs ratio of 5.5. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 10 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 70% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown is estimated using the information in the appendix to the 1994 ICI Boiler ACT document. The only O&M cost for LNBs is for administrative, property tax, and insurance, and these are estimated (in total) as 4 percent of the capital investment cost.

AT-A-GLANCE TABLE FOR POINT SOURCES

Cost Effectiveness: The default cost effectiveness value used in AirControlNET is \$1,180 per ton NOx reduced from both uncontrolled and RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNBs create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNBs create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Industrial/Commercial/Institutional (ICI) Boilers," EPA,-453/R-94-022, Research Triangle Park, NC, June 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: ICI Boilers - Distillate Oil - Small Sources

Control Measure Name: Low NOx Burner + Flue Gas Recirculation

Rule Name: Not Applicable

Pechan Measure Code: N0162S, N01602

POD: 16

Application: This control is the use of low NOx burner (LNB) technology and flue gas recirculation (FGR) to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another.

This control is applicable to small (<1 ton per OSD) distillate oil-fired ICI boilers with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

10200501 Industrial, Distillate Oil, Grades 1 and 2 Oil
10200502 Distillate Oil, 10-100 Million Btu/hr **
10200503 Distillate Oil, < 10 Million Btu/hr **
10200504 Industrial, Distillate Oil, Grade 4 Oil
10300501 Commercial/Institutional, Distillate Oil, Grades 1 and 2 Oil
10300502 Commercial/Institutional, Distillate Oil, 10-100 Million Btu/hr **
10300503 Commercial/Institutional, Distillate Oil, < 10 Million Btu/hr **
10300504 Commercial/Institutional, Distillate Oil, Grade 4 Oil

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 60% from uncontrolled

Equipment Life: 10 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by power output (Pechan, 1998).

Small source = less than 1 ton NOx per ozone season day

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). The basis of the costs are model plant data in the Alternative Control Techniques (ACT) document (EPA, 1994). From this analysis, default cost per ton values are assigned along with a capital to annual costs ratio of 5.9. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 10 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 70% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown is estimated using the detailed information in Appendix E of ICI boiler ACT document (see pages E-27 and E-28). A capacity factor of 0.58 is used in estimating the O&M cost breakdown. The model

AT-A-GLANCE TABLE FOR POINT SOURCES

boiler size used to develop cost estimates is 45 MMBtu/hr.

Electricity cost: \$0.05/kW-hr

Natural gas cost: \$3.63/MMBtu

Cost Effectiveness: The default cost effectiveness values are \$2,490 per ton NO_x reduced from uncontrolled and \$1,090 per ton NO_x reduced from RACT (1990\$).

Comments:

Status: Demonstrated	Last Reviewed: 2001
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Additional Information:

LNBS are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNBS create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNBS create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Industrial/Commercial/Institutional (ICI) Boilers," EPA,-453/R-94-022, Research Triangle Park, NC, June 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: ICI Boilers - Distillate Oil - Small Sources

Control Measure Name: Selective Catalytic Reduction (SCR)

Rule Name: Not Applicable

Pechan Measure Code: N0163S, N01603

POD: 16

Application: This control is the selective catalytic reduction of NOx through add-on controls. SCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NOx) into molecular nitrogen (N₂) and water vapor (H₂O). The SCR utilizes a catalyst to increase the NOx removal efficiency, which allows the process to occur at lower temperatures.

Applies to small (<1 ton NOx per OSD) distillate oil-fired ICI boilers with NOx emissions greater than 10 tons per year.

Affected SCC:

10200501 Industrial, Distillate Oil, Grades 1 and 2 Oil
10200502 Distillate Oil, 10-100 Million Btu/hr **
10200503 Distillate Oil, < 10 Million Btu/hr **
10200504 Industrial, Distillate Oil, Grade 4 Oil
10300501 Commercial/Institutional, Distillate Oil, Grades 1 and 2 Oil
10300502 Commercial/Institutional, Distillate Oil, 10-100 Million Btu/hr **
10300503 Commercial/Institutional, Distillate Oil, < 10 Million Btu/hr **
10300504 Commercial/Institutional, Distillate Oil, Grade 4 Oil

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 80% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NOx emission levels (Pechan, 1998).

Small source = emission levels less than 1 ton per ozone season day

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 20 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 70% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown for SCR is estimated using information from Appendix E of the ACT document (pages E-53 to E-60). This appendix provides O&M costs for 100, 150, 200, and 250 MMBtu/hour natural gas-fired boilers. The costs by category were averaged for the four boiler sizes to

AT-A-GLANCE TABLE FOR POINT SOURCES

establish a representative O&M cost breakdown for this source category/control measure combination. A capacity factor of 0.5 was used in this evaluation.

Electricity cost: \$0.05/kW-hr

Ammonia cost: \$250/ton

Cost Effectiveness: The cost effectiveness value used in AirControlNET is \$2,780 per ton NO_x reduced from uncontrolled and \$3,570 per ton NO_x from RACT baselines (1990\$).

Comments:

Status: Demonstrated	Last Reviewed: 2001
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Additional Information:

Selective Catalytic Reduction (SCR) has been widely applied to stationary source, fossil fuel-fired, combustion units for emission control since the early 1970s. SCR is typically implemented on units requiring a higher level of NO_x control than achievable by SNCR or other combustion controls (EPA, 2002).

Like SNCR, SCR is based on the chemical reduction of the NO_x molecule. The primary difference between SNCR and SCR is that SCR uses a metal-based catalyst to increase the rate of reaction (EPA, 2002). A nitrogen based reducing reagent, such as ammonia or urea, is injected into the flue gas. The reagent reacts selectively with the flue gas NO_x within a specific temperature range and in the presence of the catalyst and oxygen to reduce the NO_x.

The use of a catalyst results in two advantages of the SCR process over SNCR, the higher NO_x reduction efficiency and the lower and broader temperature ranges. However, the decrease in reaction temperature and increase in efficiency is accompanied by a significant increase in capital and operating costs (EPA, 2002). The cost increase is due to the large amount of catalyst required.

The SCR system can utilize either aqueous or anhydrous ammonia as the reagent. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Today, catalyst formulations include single component, multi-component, or active phase with a support structure. Most catalyst formulations contain additional compounds or supports, providing thermal and structural stability or to increase surface area (EPA, 2002).

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include: reaction temperature range; residence time available in the optimum temperature range; degree of mixing between the injected reagent and the combustion gases; uncontrolled NO_x concentration level; molar ratio of injected reagent to uncontrolled NO_x; ammonia slip; catalyst activity; catalyst selectivity; pressure drop across the catalyst; catalyst pitch; catalyst deactivation; and catalyst management (EPA, 2001).

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Industrial/Commercial/Institutional (ICI) Boilers," EPA-453/R-94-022, Research Triangle Park, NC, June 1994.

AT-A-GLANCE TABLE FOR POINT SOURCES

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: ICI Boilers - Distillate Oil - Small Sources

Control Measure Name: Selective Non-Catalytic Reduction (SNCR)

Rule Name: Not Applicable

Pechan Measure Code: N0164S, N01604

POD: 16

Application: This control is the reduction of NO_x emission through selective non-catalytic reduction add-on controls. SNCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NO_x) into molecular nitrogen (N₂) and water vapor (H₂O).

This control applies to small (<1 ton NO_x emissions per OSD) distillate oil IC boilers with uncontrolled NO_x emissions greater than 10 tons per year.

Affected SCC:

10200501 Industrial, Distillate Oil, Grades 1 and 2 Oil
10200502 Distillate Oil, 10-100 Million Btu/hr **
10200503 Distillate Oil, < 10 Million Btu/hr **
10200504 Industrial, Distillate Oil, Grade 4 Oil
10300501 Commercial/Institutional, Distillate Oil, Grades 1 and 2 Oil
10300502 Commercial/Institutional, Distillate Oil, 10-100 Million Btu/hr **
10300503 Commercial/Institutional, Distillate Oil, < 10 Million Btu/hr **
10300504 Commercial/Institutional, Distillate Oil, Grade 4 Oil

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 50% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NO_x emission levels (Pechan, 1998).

Small source = emission levels less than 1 ton per ozone season day

Costs for stationary source NO_x control are based on an analysis of EPA's NO_x State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned for small sources. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 20 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 70% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown is estimated using the example problem in the OAQPS Control Cost Manual chapter on SNCR. This example was for a 1,000 MMBtu/hr boiler burning sub-bituminous coal.

AT-A-GLANCE TABLE FOR POINT SOURCES

Electricity cost: \$0.05/kW-hr
Coal cost: \$1.60/MMBtu

Cost Effectiveness: The cost effectiveness values used in AirControlNET are \$4,640 per ton NO_x reduced from uncontrolled and \$3,470 per ton NO_x reduced from RACT baseline (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

SNCR is the reduction of NO_x in flue gas to N₂ and water vapor. This reduction is done with a nitrogen based reducing reagent, such as ammonia or urea. The reagent can react with a number of flue gas components. However, the NO_x reduction reaction is favored for a specific temperature range and in the presence of oxygen (EPA, 2002).

Both ammonia and urea are used as reagents. The cost of the reagent represents a large part of the annual costs of an SNCR system. Ammonia is generally less expensive than urea. However, the choice of reagent is also based on physical properties and operational considerations (EPA, 2002).

Ammonia can be utilized in either aqueous or anhydrous form. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Urea based systems have several advantages, including several safety aspects. Urea is a nontoxic, less volatile liquid that can be stored and handled more safely than ammonia. Urea solution droplets can penetrate farther into the flue gas when injected into the boiler, enhancing mixing (EPA, 2002). Because of these advantages, urea is more commonly used than ammonia in large boiler applications.

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include:

Reaction temperature range;

Residence time available in the optimum temperature range;

Degree of mixing between the injected reagent and the combustion gases

Uncontrolled NO_x concentration level;

Molar ratio of injected reagent to uncontrolled NO_x ; and ammonia slip.

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Industrial/Commercial/Institutional (ICI) Boilers," EPA,-453/R-94-022, Research Triangle Park, NC, June 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air

AT-A-GLANCE TABLE FOR POINT SOURCES

Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: ICI Boilers - Liquid Waste

Control Measure Name: Selective Catalytic Reduction (SCR)

Rule Name: Not Applicable

Pechan Measure Code: N0453S, N04503

POD: 45

Application: This control is the selective catalytic reduction of NOx through add-on controls. SCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NOx) into molecular nitrogen (N2) and water vapor (H2O). The SCR utilizes a catalyst to increase the NOx removal efficiency, which allows the process to occur at lower temperatures.

Applies to small (<1 ton NOx per OSD) liquid waste ICI boilers with NOx emissions greater than 10 tons per year.

Affected SCC:

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 80% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NOx emission levels (Pechan, 1998).

Small source = emission levels less than 1 ton per ozone season day

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 20 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 70% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown for SCR is estimated using information from Appendix E of the ACT document (pages E-53 to E-60). This appendix provides O&M costs for 100, 150, 200, and 250 MMBtu/hour natural gas-fired boilers. The costs by category were averaged for the four boiler sizes to establish a representative O&M cost breakdown for this source category/control measure combination. A capacity factor of 0.5 was used in this evaluation.

Electricity cost: \$0.05/kW-hr

Ammonia cost: \$250/ton

AT-A-GLANCE TABLE FOR POINT SOURCES

Cost Effectiveness: The cost effectiveness value used in AirControlNET is \$1,480 per ton NO_x reduced from uncontrolled and \$ 1,910 per ton NO_x reduced from RACT baselines (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

Selective Catalytic Reduction (SCR) has been widely applied to stationary source, fossil fuel-fired, combustion units for emission control since the early 1970s. SCR is typically implemented on units requiring a higher level of NO_x control than achievable by SNCR or other combustion controls (EPA, 2002).

Like SNCR, SCR is based on the chemical reduction of the NO_x molecule. The primary difference between SNCR and SCR is that SCR uses a metal-based catalyst to increase the rate of reaction (EPA, 2002). A nitrogen based reducing reagent, such as ammonia or urea, is injected into the flue gas. The reagent reacts selectively with the flue gas NO_x within a specific temperature range and in the presence of the catalyst and oxygen to reduce the NO_x.

The use of a catalyst results in two advantages of the SCR process over SNCR, the higher NO_x reduction efficiency and the lower and broader temperature ranges. However, the decrease in reaction temperature and increase in efficiency is accompanied by a significant increase in capital and operating costs (EPA, 2002). The cost increase is due to the large amount of catalyst required.

The SCR system can utilize either aqueous or anhydrous ammonia as the reagent. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Today, catalyst formulations include single component, multi-component, or active phase with a support structure. Most catalyst formulations contain additional compounds or supports, providing thermal and structural stability or to increase surface area (EPA, 2002).

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include: reaction temperature range; residence time available in the optimum temperature range; degree of mixing between the injected reagent and the combustion gases; uncontrolled NO_x concentration level; molar ratio of injected reagent to uncontrolled NO_x; ammonia slip; catalyst activity; catalyst selectivity; pressure drop across the catalyst; catalyst pitch; catalyst deactivation; and catalyst management (EPA, 2001).

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Industrial/Commercial/Institutional (ICI) Boilers," EPA-453/R-94-022, Research Triangle Park, NC, June 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity

AT-A-GLANCE TABLE FOR POINT SOURCES

Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: ICI Boilers - Liquid Waste - Small Sources

Control Measure Name: Low NOx Burner

Rule Name: Not Applicable

Pechan Measure Code: N0451S, N04501

POD: 45

Application: This control is the use of low NOx burner (LNB) technology to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another.

This control is applicable to small (<1 ton NOx per OSD) liquid waste ICI boilers with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

10201301 Industrial, Liquid Waste, Specify Waste Material in Comments

10201302 Industrial, Liquid Waste, Waste Oil

10301301 Liquid Waste, Specify Waste Material in Comments

10301302 Liquid Waste, Waste Oil

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√/*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 50% from uncontrolled

Equipment Life: 10 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NOx emission levels (Pechan, 1998).

Small source = emissions level less than 1 ton per ozone season day

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned along with a capital to annual costs ratio of 5.5. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 10 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 70% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown is estimated using the information in the appendix to the 1994 ICI Boiler ACT document. The only O&M cost for LNBs is for administrative, property tax, and insurance, and these are estimated (in total) as 4 percent of the capital investment cost.

Cost Effectiveness: The default cost effectiveness value used in AirControlNET is \$400 per ton NOx reduced from both uncontrolled and RACT (1990\$).

Comments:

AT-A-GLANCE TABLE FOR POINT SOURCES

Status: Demonstrated	Last Reviewed: 2001
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Additional Information:

LNBS are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNBS create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNBS create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Industrial/Commercial/Institutional (ICI) Boilers," EPA,-453/R-94-022, Research Triangle Park, NC, June 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: ICI Boilers - Liquid Waste - Small Sources

Control Measure Name: Low NOx Burner + Flue Gas Recirculation

Rule Name: Not Applicable

Pechan Measure Code: N0452S, N04502

POD: 45

Application: This control is the use of low NOx burner (LNB) technology and flue gas recirculation (FGR) to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another.

This control is applicable to small (<1 ton per OSD) liquid waste-fired ICI boilers with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

10201301 Industrial, Liquid Waste, Specify Waste Material in Comments

10201302 Industrial, Liquid Waste, Waste Oil

10301301 Liquid Waste, Specify Waste Material in Comments

10301302 Liquid Waste, Waste Oil

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 60% from uncontrolled

Equipment Life: 10 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by power output (Pechan, 1998).

Small source = less than 1 ton NOx per ozone season day

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). The basis of the costs are model plant data in the Alternative Control Techniques (ACT) document (EPA, 1994). From this analysis, default cost per ton values are assigned along with a capital to annual costs ratio of 5.9. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 10 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 70% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown is estimated using the detailed information in Appendix E of ICI boiler ACT document (see pages E-27 and E-28). A capacity factor of 0.58 is used in estimating the O&M cost breakdown. The model boiler size used to develop cost estimates is 45 MMBtu/hr.

Electricity cost: \$0.05/kW-hr

Natural gas cost: \$3.63/MMBtu

AT-A-GLANCE TABLE FOR POINT SOURCES

Cost Effectiveness: The default cost effectiveness values are \$1,120 per ton NO_x reduced from uncontrolled and \$1,080 per ton NO_x reduced from RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNBs create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNBs create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Industrial/Commercial/Institutional (ICI) Boilers," EPA,-453/R-94-022, Research Triangle Park, NC, June 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: ICI Boilers - Liquid Waste - Small Sources

Control Measure Name: Selective Non-Catalytic Reduction (SNCR)

Rule Name: Not Applicable

Pechan Measure Code: N0454S

POD: 45

Application: This control is the reduction of NO_x emission through selective non-catalytic reduction add-on controls. SNCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NO_x) into molecular nitrogen (N₂) and water vapor (H₂O).

This control applies to small (<1 ton NO_x emissions per OSD) liquid waste-fired IC boilers with uncontrolled NO_x emissions greater than 10 tons per year, classified under the following SCCs: 10201301, 10201302, 10301301, and 10301302.

Affected SCC:

10201301 Industrial, Liquid Waste, Specify Waste Material in Comments

10201302 Industrial, Liquid Waste, Waste Oil

10301301 Liquid Waste, Specify Waste Material in Comments

10301302 Liquid Waste, Waste Oil

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 50% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NO_x emission levels (Pechan, 1998).

Small source = emission levels less than 1 ton per ozone season day

Costs for stationary source NO_x control are based on an analysis of EPA's NO_x State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned for small sources. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 20 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 70% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown is estimated using the example problem in the OAQPS Control Cost Manual chapter on SNCR. This example was for a 1,000 MMBtu/hr boiler burning sub-bituminous coal.

Electricity cost: \$0.05/kW-hr

Coal cost: \$1.60/MMBtu

AT-A-GLANCE TABLE FOR POINT SOURCES

Cost Effectiveness: The cost effectiveness values used in AirControlNET are \$2,580 per ton NO_x reduced from uncontrolled and \$1,940 per ton NO_x reduced from RACT baseline (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

SNCR is the reduction of NO_x in flue gas to N₂ and water vapor. This reduction is done with a nitrogen based reducing reagent, such as ammonia or urea. The reagent can react with a number of flue gas components. However, the NO_x reduction reaction is favored for a specific temperature range and in the presence of oxygen (EPA, 2002).

Both ammonia and urea are used as reagents. The cost of the reagent represents a large part of the annual costs of an SNCR system. Ammonia is generally less expensive than urea. However, the choice of reagent is also based on physical properties and operational considerations (EPA, 2002).

Ammonia can be utilized in either aqueous or anhydrous form. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Urea based systems have several advantages, including several safety aspects. Urea is a nontoxic, less volatile liquid that can be stored and handled more safely than ammonia. Urea solution droplets can penetrate farther into the flue gas when injected into the boiler, enhancing mixing (EPA, 2002). Because of these advantages, urea is more commonly used than ammonia in large boiler applications.

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include:

Reaction temperature range;
Residence time available in the optimum temperature range;
Degree of mixing between the injected reagent and the combustion gases
Uncontrolled NO_x concentration level;
Molar ratio of injected reagent to uncontrolled NO_x ; and
Ammonia slip.

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Industrial/Commercial/Institutional (ICI) Boilers," EPA,-453/R-94-022, Research Triangle Park, NC, June 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

AT-A-GLANCE TABLE FOR POINT SOURCES

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: ICI Boilers - LPG - Small Sources

Control Measure Name: Low NOx Burner

Rule Name: Not Applicable

Pechan Measure Code: N0431S, N04301

POD: 43

Application: This control is the use of low NOx burner (LNB) technology to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another.

This control is applicable to small (<1 ton NOx per OSD) LPG ICI boilers with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

10201001 Liquefied Petroleum Gas (LPG), Butane

10201002 Industrial, Liquefied Petroleum Gas (LPG), Propane

10301002 Commercial/Institutional, Liquefied Petroleum Gas (LPG), Propane

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 50% from uncontrolled

Equipment Life: 10 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NOx emission levels (Pechan, 1998).

Small source = emissions level less than 1 ton per ozone season day

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned along with a capital to annual costs ratio of 5.5. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 10 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 70% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown is estimated using the information in the appendix to the 1994 ICI Boiler ACT document. The only O&M cost for LNBs is for administrative, property tax, and insurance, and these are estimated (in total) as 4 percent of the capital investment cost.

Cost Effectiveness: The default cost effectiveness value used in AirControlINET is \$1,180 per ton NOx reduced from both uncontrolled and RACT (1990\$).

Comments:

AT-A-GLANCE TABLE FOR POINT SOURCES

Status: Demonstrated	Last Reviewed: 2001
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Additional Information:

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNBs create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNBs create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Industrial/Commercial/Institutional (ICI) Boilers," EPA,-453/R-94-022, Research Triangle Park, NC, June 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: ICI Boilers - LPG - Small Sources

Control Measure Name: Low NOx Burner + Flue Gas Recirculation

Rule Name: Not Applicable

Pechan Measure Code: N0432S, N04302

POD: 43

Application: This control is the use of low NOx burner (LNB) technology and flue gas recirculation (FGR) to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another.

This control is applicable to small (<1 ton per OSD) LPG-fired ICI boilers with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

10201001 Liquefied Petroleum Gas (LPG), Butane

10201002 Industrial, Liquefied Petroleum Gas (LPG), Propane

10301002 Commercial/Institutional, Liquefied Petroleum Gas (LPG), Propane

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 60% from uncontrolled

Equipment Life: 10 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by power output (Pechan, 1998).

Small source = less than 1 ton NOx per ozone season day

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). The basis of the costs are model plant data in the Alternative Control Techniques (ACT) document (EPA, 1994). From this analysis, default cost per ton values are assigned along with a capital to annual costs ratio of 5.9. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 10 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 70% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown is estimated using the detailed information in Appendix E of ICI boiler ACT document (see pages E-27 and E-28). A capacity factor of 0.58 is used in estimating the O&M cost breakdown. The model boiler size used to develop cost estimates is 45 MMBtu/hr.

Electricity cost: \$0.05/kW-hr

Natural gas cost: \$3.63/MMBtu

AT-A-GLANCE TABLE FOR POINT SOURCES

Cost Effectiveness: The default cost effectiveness values are \$2,490 per ton NO_x reduced from uncontrolled and \$1,090 per ton NO_x reduced from RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNBs create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNBs create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Industrial/Commercial/Institutional (ICI) Boilers," EPA,-453/R-94-022, Research Triangle Park, NC, June 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: ICI Boilers - LPG - Small Sources

Control Measure Name: Selective Catalytic Reduction (SCR)

Rule Name: Not Applicable

Pechan Measure Code: N0433S, N04303

POD: 43

Application: This control is the selective catalytic reduction of NO_x through add-on controls. SCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NO_x) into molecular nitrogen (N₂) and water vapor (H₂O). The SCR utilizes a catalyst to increase the NO_x removal efficiency, which allows the process to occur at lower temperatures.

Applies to small (<1 ton NO_x per OSD) LPG ICI boilers with NO_x emissions greater than 10 tons per year.

Affected SCC:

10201001 Liquefied Petroleum Gas (LPG), Butane

10201002 Industrial, Liquefied Petroleum Gas (LPG), Propane

10301002 Commercial/Institutional, Liquefied Petroleum Gas (LPG), Propane

Pollutant(s)	PM10	PM2.5	EC	OC	NO _x	VOC	SO ₂	NH ₃	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 80% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NO_x emission levels (Pechan, 1998).

Small source = emission levels less than 1 ton per ozone season day

Costs for stationary source NO_x control are based on an analysis of EPA's NO_x State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 20 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 70% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown for SCR is estimated using information from Appendix E of the ACT document (pages E-53 to E-60). This appendix provides O&M costs for 100, 150, 200, and 250 MMBtu/hour natural gas-fired boilers. The costs by category were averaged for the four boiler sizes to establish a representative O&M cost breakdown for this source category/control measure combination. A capacity factor of 0.5 was used in this evaluation.

Electricity cost: \$0.05/kW-hr

Ammonia cost: \$250/ton

AT-A-GLANCE TABLE FOR POINT SOURCES

Cost Effectiveness: The cost effectiveness value used in AirControlNET is \$2,780 per ton NO_x reduced from uncontrolled and \$3,570 per ton NO_x reduced from RACT baselines (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

Selective Catalytic Reduction (SCR) has been widely applied to stationary source, fossil fuel-fired, combustion units for emission control since the early 1970s. SCR is typically implemented on units requiring a higher level of NO_x control than achievable by SNCR or other combustion controls (EPA, 2002).

Like SNCR, SCR is based on the chemical reduction of the NO_x molecule. The primary difference between SNCR and SCR is that SCR uses a metal-based catalyst to increase the rate of reaction (EPA, 2002). A nitrogen based reducing reagent, such as ammonia or urea, is injected into the flue gas. The reagent reacts selectively with the flue gas NO_x within a specific temperature range and in the presence of the catalyst and oxygen to reduce the NO_x.

The use of a catalyst results in two advantages of the SCR process over SNCR, the higher NO_x reduction efficiency and the lower and broader temperature ranges. However, the decrease in reaction temperature and increase in efficiency is accompanied by a significant increase in capital and operating costs (EPA, 2002). The cost increase is due to the large amount of catalyst required.

The SCR system can utilize either aqueous or anhydrous ammonia as the reagent. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Today, catalyst formulations include single component, multi-component, or active phase with a support structure. Most catalyst formulations contain additional compounds or supports, providing thermal and structural stability or to increase surface area (EPA, 2002).

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include: reaction temperature range; residence time available in the optimum temperature range; degree of mixing between the injected reagent and the combustion gases; uncontrolled NO_x concentration level; molar ratio of injected reagent to uncontrolled NO_x; ammonia slip; catalyst activity; catalyst selectivity; pressure drop across the catalyst; catalyst pitch; catalyst deactivation; and catalyst management (EPA, 2001).

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Industrial/Commercial/Institutional (ICI) Boilers," EPA-453/R-94-022, Research Triangle Park, NC, June 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity

AT-A-GLANCE TABLE FOR POINT SOURCES

Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: ICI Boilers - LPG - Small Sources

Control Measure Name: Selective Non-Catalytic Reduction (SNCR)

Rule Name: Not Applicable

Pechan Measure Code: N0434S, N04304

POD: 43

Application: This control is the reduction of NO_x emission through selective non-catalytic reduction add-on controls. SNCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NO_x) into molecular nitrogen (N₂) and water vapor (H₂O).

This control applies to small (<1 ton NO_x emissions per OSD) liquid petroleum gas-fired IC boilers with uncontrolled NO_x emissions greater than 10 tons per year, classified under SCCs 10201001, 10201002, and 10301002.

Affected SCC:

10201001 Liquefied Petroleum Gas (LPG), Butane

10201002 Industrial, Liquefied Petroleum Gas (LPG), Propane

10301002 Commercial/Institutional, Liquefied Petroleum Gas (LPG), Propane

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√/*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 50% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NO_x emission levels (Pechan, 1998).

Small source = emission levels less than 1 ton per ozone season day

Costs for stationary source NO_x control are based on an analysis of EPA's NO_x State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned for small sources. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 20 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 70% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown is estimated using the example problem in the OAQPS Control Cost Manual chapter on SNCR. This example was for a 1,000 MMBtu/hr boiler burning sub-bituminous coal.

Electricity cost: \$0.05/kW-hr

Coal cost: \$1.60/MMBtu

Cost Effectiveness: The cost effectiveness values used in AirControlNET are \$4,640 per ton NO_x

AT-A-GLANCE TABLE FOR POINT SOURCES

reduced from uncontrolled and \$ 3,470 per ton NO_x reduced from RACT baseline (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

SNCR is the reduction of NO_x in flue gas to N₂ and water vapor. This reduction is done with a nitrogen based reducing reagent, such as ammonia or urea. The reagent can react with a number of flue gas components. However, the NO_x reduction reaction is favored for a specific temperature range and in the presence of oxygen (EPA, 2002).

Both ammonia and urea are used as reagents. The cost of the reagent represents a large part of the annual costs of an SNCR system. Ammonia is generally less expensive than urea. However, the choice of reagent is also based on physical properties and operational considerations (EPA, 2002).

Ammonia can be utilized in either aqueous or anhydrous form. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Urea based systems have several advantages, including several safety aspects. Urea is a nontoxic, less volatile liquid that can be stored and handled more safely than ammonia. Urea solution droplets can penetrate farther into the flue gas when injected into the boiler, enhancing mixing (EPA, 2002). Because of these advantages, urea is more commonly used than ammonia in large boiler applications.

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include:

Reaction temperature range;
Residence time available in the optimum temperature range;
Degree of mixing between the injected reagent and the combustion gases
Uncontrolled NO_x concentration level;
Molar ratio of injected reagent to uncontrolled NO_x ; and
Ammonia slip.

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Industrial/Commercial/Institutional (ICI) Boilers," EPA,-453/R-94-022, Research Triangle Park, NC, June 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

AT-A-GLANCE TABLE FOR POINT SOURCES

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: ICI Boilers - MSW/Stoker - Small Sources

Control Measure Name: Selective Non-Catalytic Reduction (SNCR) Urea Based

Rule Name: Not Applicable

Pechan Measure Code: N0201S, N02001

POD: 20

Application: This control is the reduction of NO_x emission through urea based selective non-catalytic reduction add-on controls. SNCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NO_x) into molecular nitrogen (N₂) and water vapor (H₂O).

This control applies to small (<1 ton NO_x emissions per OSD) solid waste/stoker IC boilers with uncontrolled NO_x emissions greater than 10 tons per year.

Affected SCC:

10201201 Industrial, Solid Waste, Specify Waste Material in Comments

10301201 Solid Waste, Specify Waste Material in Comments

10301202 Solid Waste, Refuse Derived Fuel

Pollutant(s)	PM10	PM2.5	EC	OC	NO _x	VOC	SO ₂	NH ₃	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 55% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NO_x emission levels (Pechan, 1998).

Small source = emission levels less than 1 ton per ozone season day

Costs for stationary source NO_x control are based on an analysis of EPA's NO_x State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned for small sources. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 20 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 70% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown is estimated using the example problem in the OAQPS Control Cost Manual chapter on SNCR. This example was for a 1,000 MMBtu/hr boiler burning sub-bituminous coal.

Electricity cost: \$0.05/kW-hr

Coal cost: \$1.60/MMBtu

Cost Effectiveness: The cost effectiveness used in AirControlNET for both reductions from baseline and reductions from RACT is \$1,690 per ton NO_x reduced (1990\$).

AT-A-GLANCE TABLE FOR POINT SOURCES

Comments:**Status:** Demonstrated**Last Reviewed:** 2001

Additional Information:

SNCR is the reduction of NO_x in flue gas to N₂ and water vapor. This reduction is done with a nitrogen based reducing reagent, such as ammonia or urea. The reagent can react with a number of flue gas components. However, the NO_x reduction reaction is favored for a specific temperature range and in the presence of oxygen (EPA, 2002).

Urea based systems have several advantages, including several safety aspects. Urea is a nontoxic, less volatile liquid that can be stored and handled more safely than ammonia. Urea solution droplets can penetrate farther into the flue gas when injected into the boiler, enhancing mixing (EPA, 2002). Because of these advantages, urea is more commonly used than ammonia in large boiler applications.

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include:

Reaction temperature range;

Residence time available in the optimum temperature range;

Degree of mixing between the injected reagent and the combustion gases

Uncontrolled NO_x concentration level;

Molar ratio of injected reagent to uncontrolled NO_x ; and ammonia slip.

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Industrial/Commercial/Institutional (ICI) Boilers," EPA,-453/R-94-022, Research Triangle Park, NC, June 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: ICI Boilers - Natural Gas - Large Sources

Control Measure Name: Selective Non-Catalytic Reduction (SNCR)

Rule Name: Not Applicable

Pechan Measure Code: N0175L, N01705

POD: 17

Application: This control is the reduction of NOx emission through selective non-catalytic reduction add-on controls. SNCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NOx) into molecular nitrogen (N2) and water vapor (H2O).

This control applies to large (>1 ton NOx emissions per OSD) natural gas fired IC boilers with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

10200601 Industrial, Natural Gas, > 100 Million Btu/hr
10200602 Industrial, Natural Gas, 10-100 Million Btu/hr
10200603 Industrial, Natural Gas, < 10 Million Btu/hr
10200604 Natural Gas, Cogeneration
10201401 CO Boiler, Natural Gas
10300601 Commercial/Institutional, Natural Gas, > 100 Million Btu/hr
10300602 Commercial/Institutional, Natural Gas, 10-100 Million Btu/hr
10300603 Commercial/Institutional, Natural Gas, < 10 Million Btu/hr

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 50% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NOx emission levels (Pechan, 1998).

Large source = emission levels greater than 1 ton per ozone season day

Where information was available in the Alternative Control Techniques (ACT) document (EPA, 1994), capacity-based equations are used to calculate costs. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 20 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 70% (Pechan, 2001).

The following equations, based primarily on information in the Air Pollution Cost Manual (EPA, 2002), are used for large NOx sources as defined above:

From Uncontrolled:

AT-A-GLANCE TABLE FOR POINT SOURCES

Capital Cost = $62,148.8 * \text{Capacity (MMBtu/hr)}^{0.423}$
Annual Cost = $2,012.4 * \text{Capacity (MMBtu/hr)}^{0.7229}$

O&M Cost Components: The O&M cost breakdown is estimated using the example problem in the OAQPS Control Cost Manual chapter on SNCR. This example was for a 1,000 MMBtu/hr boiler burning sub-bituminous coal.

Electricity cost: \$0.05/kW-hr
Coal cost: \$1.60/MMBtu

From RACT Baseline:

Capital Cost = $48,002.6 * \text{Capacity (MMBtu/hr)}^{0.423}$
Annual Cost = $5,244.4 * \text{Capacity (MMBtu/hr)}^{0.4238}$

Note: All costs are in 1990 dollars.

Cost Effectiveness: When capacity is available and within the applicable range of 0 to 2,000 MMBTU/hr the cost equations are used to calculate cost effectiveness. The default cost effectiveness value, used when capacity information is not available, is \$1,570 per ton NO_x reduced from uncontrolled and \$840 per ton NO_x reduced from RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

SNCR is the reduction of NO_x in flue gas to N₂ and water vapor. This reduction is done with a nitrogen based reducing reagent, such as ammonia or urea. The reagent can react with a number of flue gas components. However, the NO_x reduction reaction is favored for a specific temperature range and in the presence of oxygen (EPA, 2002).

Both ammonia and urea are used as reagents. The cost of the reagent represents a large part of the annual costs of an SNCR system. Ammonia is generally less expensive than urea. However, the choice of reagent is also based on physical properties and operational considerations (EPA, 2002).

Ammonia can be utilized in either aqueous or anhydrous form. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Urea based systems have several advantages, including several safety aspects. Urea is a nontoxic, less volatile liquid that can be stored and handled more safely than ammonia. Urea solution droplets can penetrate farther into the flue gas when injected into the boiler, enhancing mixing (EPA, 2002). Because of these advantages, urea is more commonly used than ammonia in large boiler applications.

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include:

Reaction temperature range;
Residence time available in the optimum temperature range;

AT-A-GLANCE TABLE FOR POINT SOURCES

Degree of mixing between the injected reagent and the combustion gases
Uncontrolled NO_x concentration level;
Molar ratio of injected reagent to uncontrolled NO_x ; and ammonia slip.

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Industrial/Commercial/Institutional (ICI) Boilers," EPA,-453/R-94-022, Research Triangle Park, NC, June 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: ICI Boilers - Natural Gas - Small Sources

Control Measure Name: Low NOx Burner

Rule Name: Not Applicable

Pechan Measure Code: N0171S, N01701

POD: 17

Application: This control is the use of low NOx burner (LNB) technology to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another.

This control is applicable to small (<1 ton NOx per OSD) natural gas fired ICI boilers with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

10200601 Industrial, Natural Gas, > 100 Million Btu/hr
10200602 Industrial, Natural Gas, 10-100 Million Btu/hr
10200603 Industrial, Natural Gas, < 10 Million Btu/hr
10200604 Natural Gas, Cogeneration
10201401 CO Boiler, Natural Gas
10300601 Commercial/Institutional, Natural Gas, > 100 Million Btu/hr
10300602 Commercial/Institutional, Natural Gas, 10-100 Million Btu/hr
10300603 Commercial/Institutional, Natural Gas, < 10 Million Btu/hr

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 50% from uncontrolled

Equipment Life: 10 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NOx emission levels (Pechan, 1998).

Small source = emissions level less than 1 ton per ozone season day

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned along with a capital to annual costs ratio of 5.5. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 10 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 70% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown is estimated using the information in the appendix to the 1994 ICI Boiler ACT document. The only O&M cost for LNBs is for administrative, property tax, and insurance, and these are estimated (in total) as 4 percent of the capital investment cost.

AT-A-GLANCE TABLE FOR POINT SOURCES

Cost Effectiveness: The default cost effectiveness value used in AirControlNET is \$820 per ton NOx reduced from both uncontrolled and RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNBs create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNBs create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Industrial/Commercial/Institutional (ICI) Boilers," EPA,-453/R-94-022, Research Triangle Park, NC, June 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: ICI Boilers - Natural Gas - Small Sources

Control Measure Name: Low NOx Burner + Flue Gas Recirculation

Rule Name: Not Applicable

Pechan Measure Code: N0172S, N01702

POD: 17

Application: This control is the use of low NOx burner (LNB) technology and flue gas recirculation (FGR) to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another.

This control is applicable to small (<1 ton per OSD) natural gas-fired ICI boilers with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

10200601 Industrial, Natural Gas, > 100 Million Btu/hr
10200602 Industrial, Natural Gas, 10-100 Million Btu/hr
10200603 Industrial, Natural Gas, < 10 Million Btu/hr
10200604 Natural Gas, Cogeneration
10201401 CO Boiler, Natural Gas
10300601 Commercial/Institutional, Natural Gas, > 100 Million Btu/hr
10300602 Commercial/Institutional, Natural Gas, 10-100 Million Btu/hr
10300603 Commercial/Institutional, Natural Gas, < 10 Million Btu/hr

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 60% from uncontrolled

Equipment Life: 10 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 70% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown is estimated using the detailed information in Appendix E of ICI boiler ACT document (see pages E-27 and E-28). A capacity factor of 0.58 is used in estimating the O&M cost breakdown. The model boiler size used to develop cost estimates is 45 MMBtu/hr.

Electricity cost: \$0.05/kW-hr

Natural gas cost: \$3.63/MMBtu

Cost Effectiveness: The default cost effectiveness values are \$2,560 per ton NOx reduced from uncontrolled and \$2,470 per ton NOx reduced from RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNBs create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNBs create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Industrial/Commercial/Institutional (ICI) Boilers," EPA,-453/R-94-022, Research Triangle Park, NC, June 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: ICI Boilers - Natural Gas - Small Sources

Control Measure Name: Oxygen Trim + Water Injection

Rule Name: Not Applicable

Pechan Measure Code: N0173S, N01703

POD: 17

Application: This control is the use of OT + WI to reduce NOx emissions.

This control applies to small (<1 ton NOx per OSD) natural gas-fired ICI boilers with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

10200601 Industrial, Natural Gas, > 100 Million Btu/hr
10200602 Industrial, Natural Gas, 10-100 Million Btu/hr
10200603 Industrial, Natural Gas, < 10 Million Btu/hr
10200604 Natural Gas, Cogeneration
10201401 CO Boiler, Natural Gas
10300601 Commercial/Institutional, Natural Gas, > 100 Million Btu/hr
10300602 Commercial/Institutional, Natural Gas, 10-100 Million Btu/hr
10300603 Commercial/Institutional, Natural Gas, < 10 Million Btu/hr

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 65% from uncontrolled

Equipment Life: 10 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by power output (Pechan, 1998).

Small source = less than 1 ton NOx per ozone season day

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). The basis of the costs are model plant data in the Alternative Control Techniques (ACT) document (EPA, 1994). The model boiler size used to develop cost estimates is 45 MMBtu/hr. From this analysis, default cost per ton values are assigned along with a capital to annual costs ratio of 2.9. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 10 years (EPA, 1994). The 7 percent discount rate used as a baseline in AirControlNET is changed from the 10 percent rate used in the ACT document.

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 70% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown is estimated using the detailed information in Appendix E of the ACT document. (See pages E-3 and E-4.) A capacity factor of 0.58 is used in estimating the O&M cost breakdown.

AT-A-GLANCE TABLE FOR POINT SOURCES

Electricity Cost: \$0.05/kW-hr
Natural Gas Cost: \$3.63/MMBtu

Cost Effectiveness: The default cost effectiveness value is \$680 per ton NO_x reduced from both uncontrolled and RACT baselines (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

Water is injected into the gas turbine, reducing the temperatures in the NO_x-forming regions. The water can be injected into the fuel, the combustion air or directly into the combustion chamber (ERG, 2000).

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Industrial/Commercial/Institutional (ICI) Boilers," EPA,-453/R-94-022, Research Triangle Park, NC, June 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

ERG, 2000: Eastern Research Group, Inc., "How to Incorporate the Effects of Air Pollution Control Device Efficiencies and Malfunctions into Emission Inventory Estimates," prepared for Emission Inventory Improvement Program, Point Sources Committee, July 2000.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: ICI Boilers - Natural Gas - Small Sources

Control Measure Name: Selective Catalytic Reduction (SCR)

Rule Name: Not Applicable

Pechan Measure Code: N0174S, N01704

POD: 17

Application: This control is the selective catalytic reduction of NOx through add-on controls. SCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NOx) into molecular nitrogen (N2) and water vapor (H2O). The SCR utilizes a catalyst to increase the NOx removal efficiency, which allows the process to occur at lower temperatures.

Applies to small (<1 ton NOx per OSD) natural gas fired ICI boilers with NOx emissions greater than 10 tons per year.

Affected SCC:

10200601 Industrial, Natural Gas, > 100 Million Btu/hr
10200602 Industrial, Natural Gas, 10-100 Million Btu/hr
10200603 Industrial, Natural Gas, < 10 Million Btu/hr
10200604 Natural Gas, Cogeneration
10201401 CO Boiler, Natural Gas
10300601 Commercial/Institutional, Natural Gas, > 100 Million Btu/hr
10300602 Commercial/Institutional, Natural Gas, 10-100 Million Btu/hr
10300603 Commercial/Institutional, Natural Gas, < 10 Million Btu/hr

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 80% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NOx emission levels (Pechan, 1998).

Small source = emission levels less than 1 ton per ozone season day

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 20 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 70% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown for SCR is estimated using information from Appendix E of the ACT document (pages E-53 to E-60). This appendix provides O&M costs for 100, 150, 200, and 250 MMBtu/hour natural gas-fired boilers. The costs by category were averaged for the four boiler sizes to

AT-A-GLANCE TABLE FOR POINT SOURCES

establish a representative O&M cost breakdown for this source category/control measure combination. A capacity factor of 0.5 was used in this evaluation.

Electricity cost: \$0.05/kW-hr

Ammonia cost: \$250/ton

Cost Effectiveness: The cost effectiveness values used in AirControlNET are \$2,230 per ton NOx reduced from uncontrolled and \$2,860 per ton NOx reduced from RACT baselines (1990\$).

Comments:

Status: Demonstrated	Last Reviewed: 2001
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Additional Information:

Selective Catalytic Reduction (SCR) has been widely applied to stationary source, fossil fuel-fired, combustion units for emission control since the early 1970s. SCR is typically implemented on units requiring a higher level of NOx control than achievable by SNCR or other combustion controls (EPA, 2002).

Like SNCR, SCR is based on the chemical reduction of the NOx molecule. The primary difference between SNCR and SCR is that SCR uses a metal-based catalyst to increase the rate of reaction (EPA, 2002). A nitrogen based reducing reagent, such as ammonia or urea, is injected into the flue gas. The reagent reacts selectively with the flue gas NOx within a specific temperature range and in the presence of the catalyst and oxygen to reduce the NOx.

The use of a catalyst results in two advantages of the SCR process over SNCR, the higher NOx reduction efficiency and the lower and broader temperature ranges. However, the decrease in reaction temperature and increase in efficiency is accompanied by a significant increase in capital and operating costs (EPA, 2002). The cost increase is due to the large amount of catalyst required.

The SCR system can utilize either aqueous or anhydrous ammonia as the reagent. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Today, catalyst formulations include single component, multi-component, or active phase with a support structure. Most catalyst formulations contain additional compounds or sup-ports, providing thermal and structural stability or to increase surface area (EPA, 2002).

The rate of reaction determines the amount of NOx removed from the flue gas. The important design and operational factors that affect the rate of reduction include: reaction temperature range; residence time available in the optimum temperature range; degree of mixing between the injected reagent and the combustion gases; uncontrolled NOx concentration level; molar ratio of injected reagent to uncontrolled NOx; ammonia slip; catalyst activity; catalyst selectivity; pressure drop across the catalyst; catalyst pitch; catalyst deactivation; and catalyst management (EPA, 2001).

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Industrial/Commercial/Institutional (ICI) Boilers," EPA-453/R-94-022, Research Triangle Park, NC, June 1994.

AT-A-GLANCE TABLE FOR POINT SOURCES

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: ICI Boilers - Natural Gas - Small Sources

Control Measure Name: Selective Non-Catalytic Reduction (SNCR)

Rule Name: Not Applicable

Pechan Measure Code: N0175S

POD: 17

Application: This control is the reduction of NO_x emission through selective non-catalytic reduction add-on controls. SNCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NO_x) into molecular nitrogen (N₂) and water vapor (H₂O).

This control applies to small (<1 ton NO_x emissions per OSD) natural gas-fired IC boilers with uncontrolled NO_x emissions greater than 10 tons per year.

Affected SCC:

10200601 Industrial, Natural Gas, > 100 Million Btu/hr
10200602 Industrial, Natural Gas, 10-100 Million Btu/hr
10200603 Industrial, Natural Gas, < 10 Million Btu/hr
10200604 Natural Gas, Cogeneration
10201401 CO Boiler, Natural Gas
10300601 Commercial/Institutional, Natural Gas, > 100 Million Btu/hr
10300602 Commercial/Institutional, Natural Gas, 10-100 Million Btu/hr
10300603 Commercial/Institutional, Natural Gas, < 10 Million Btu/hr

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 50% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NO_x emission levels (Pechan, 1998).

Small source = emission levels less than 1 ton per ozone season day

Costs for stationary source NO_x control are based on an analysis of EPA's NO_x State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned for small sources. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 20 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 70% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown is estimated using the example problem in the OAQPS Control Cost Manual chapter on SNCR. This example was for a 1,000 MMBtu/hr boiler burning sub-bituminous coal.

AT-A-GLANCE TABLE FOR POINT SOURCES

Electricity cost: \$0.05/kW-hr
Coal cost: \$1.60/MMBtu

Cost Effectiveness: The cost effectiveness values used in AirControlNET are \$3,870 per ton NO_x reduced from uncontrolled and \$2,900 per ton NO_x reduced from RACT baseline (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

SNCR is the reduction of NO_x in flue gas to N₂ and water vapor. This reduction is done with a nitrogen based reducing reagent, such as ammonia or urea. The reagent can react with a number of flue gas components. However, the NO_x reduction reaction is favored for a specific temperature range and in the presence of oxygen (EPA, 2002).

Both ammonia and urea are used as reagents. The cost of the reagent represents a large part of the annual costs of an SNCR system. Ammonia is generally less expensive than urea. However, the choice of reagent is also based on physical properties and operational considerations (EPA, 2002).

Ammonia can be utilized in either aqueous or anhydrous form. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Urea based systems have several advantages, including several safety aspects. Urea is a nontoxic, less volatile liquid that can be stored and handled more safely than ammonia. Urea solution droplets can penetrate farther into the flue gas when injected into the boiler, enhancing mixing (EPA, 2002). Because of these advantages, urea is more commonly used than ammonia in large boiler applications.

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include:

Reaction temperature range;

Residence time available in the optimum temperature range;

Degree of mixing between the injected reagent and the combustion gases

Uncontrolled NO_x concentration level;

Molar ratio of injected reagent to uncontrolled NO_x ; and ammonia slip.

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Industrial/Commercial/Institutional (ICI) Boilers," EPA,-453/R-94-022, Research Triangle Park, NC, June 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air

AT-A-GLANCE TABLE FOR POINT SOURCES

Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: ICI Boilers - Process Gas - Small Sources

Control Measure Name: Low NOx Burner

Rule Name: Not Applicable

Pechan Measure Code: N0411S, N04101

POD: 41

Application: This control is the use of low NOx burner (LNB) technology to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another.

This control is applicable to small (<1 ton NOx per OSD) process gas fired ICI boilers with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

10200701 Industrial, Process Gas, Petroleum Refinery Gas
10200702 Industrial, Process Gas
10200704 Process Gas, Blast Furnace Gas
10200707 Industrial, Process Gas, Coke Oven Gas
10200710 Process Gas, Cogeneration
10200799 Process Gas, Other: Specify in Comments
10201402 CO Boiler, Process Gas
10300701 Commercial/Institutional, Process Gas, POTW Digester Gas-fired Boiler
10300799 Commercial/Institutional, Process Gas, Other Not Classified

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 50% from uncontrolled

Equipment Life: 10 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NOx emission levels (Pechan, 1998).

Small source = emissions level less than 1 ton per ozone season day

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned along with a capital to annual costs ratio of 5.5. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 10 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 70% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown is estimated using the information in the appendix to the 1994 ICI Boiler ACT document. The only O&M cost for LNBs is for administrative, property tax, and insurance, and these are estimated

AT-A-GLANCE TABLE FOR POINT SOURCES

(in total) as 4 percent of the capital investment cost.

Cost Effectiveness: The default cost effectiveness value used in AirControlNET is \$820 per ton NOx reduced from both uncontrolled and RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNBs create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNBs create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Industrial/Commercial/Institutional (ICI) Boilers," EPA,-453/R-94-022, Research Triangle Park, NC, June 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: ICI Boilers - Process Gas - Small Sources

Control Measure Name: Low NOx Burner + Flue Gas Recirculation

Rule Name: Not Applicable

Pechan Measure Code: N0412S, N04102

POD: 41

Application: This control is the use of low NOx burner (LNB) technology and flue gas recirculation (FGR) to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another.

This control is applicable to small (<1 ton per OSD) process gas-fired ICI boilers with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

10200701 Industrial, Process Gas, Petroleum Refinery Gas
10200702 Industrial, Process Gas
10200704 Process Gas, Blast Furnace Gas
10200707 Industrial, Process Gas, Coke Oven Gas
10200710 Process Gas, Cogeneration
10200799 Process Gas, Other: Specify in Comments
10201402 CO Boiler, Process Gas
10300701 Commercial/Institutional, Process Gas, POTW Digester Gas-fired Boiler
10300799 Commercial/Institutional, Process Gas, Other Not Classified

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 60% from uncontrolled

Equipment Life: 10 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by power output (Pechan, 1998).

Small source = less than 1 ton NOx per ozone season day

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). The basis of the costs are model plant data in the Alternative Control Techniques (ACT) document (EPA, 1994). From this analysis, default cost per ton values are assigned along with a capital to annual costs ratio of 5.9. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 10 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 70% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown is estimated using the detailed information in Appendix E of ICI boiler ACT document (see pages E-27 and E-28). A

AT-A-GLANCE TABLE FOR POINT SOURCES

capacity factor of 0.58 is used in estimating the O&M cost breakdown. The model boiler size used to develop cost estimates is 45 MMBtu/hr.

Electricity cost: \$0.05/kW-hr
Natural gas cost: \$3.63/MMBtu

Cost Effectiveness: The default cost effectiveness values are \$2,560 per ton NO_x reduced from uncontrolled and \$2,470 per ton NO_x reduced from RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNBs create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNBs create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Industrial/Commercial/Institutional (ICI) Boilers," EPA,-453/R-94-022, Research Triangle Park, NC, June 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: ICI Boilers - Process Gas - Small Sources

Control Measure Name: Oxygen Trim + Water Injection

Rule Name: Not Applicable

Pechan Measure Code: N0413S, N04103

POD: 41

Application: This control is the use of OT + WI to reduce NOx emissions.

This control applies to small (<1 ton NOx per OSD) process gas-fired reformers involved in ammonia production with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

10200701 Industrial, Process Gas, Petroleum Refinery Gas

10200702 Industrial, Process Gas

10200704 Process Gas, Blast Furnace Gas

10200707 Industrial, Process Gas, Coke Oven Gas

10200710 Process Gas, Cogeneration

10200799 Process Gas, Other: Specify in Comments

10201402 CO Boiler, Process Gas

10300701 Commercial/Institutional, Process Gas, POTW Digester Gas-fired Boiler

10300799 Commercial/Institutional, Process Gas, Other Not Classified

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 65% from uncontrolled

Equipment Life: 10 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by power output (Pechan, 1998).

Small source = less than 1 ton NOx per ozone season day

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). The basis of the costs are model plant data in the Alternative Control Techniques (ACT) document (EPA, 1994). From this analysis, default cost per ton values are assigned along with a capital to annual costs ratio of 2.9. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 10 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 70% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown is estimated using the detailed information in Appendix E of the ACT document. (See pages E-3 and E-4.) A capacity factor of 0.58 is used in estimating the O&M cost breakdown.

AT-A-GLANCE TABLE FOR POINT SOURCES

Electricity Cost: \$0.05/kW-hr
Natural Gas Cost: \$3.63/MMBtu

Cost Effectiveness: The default cost effectiveness value is \$680 per ton NO_x reduced from both uncontrolled and RACT baselines (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

Water is injected into the gas turbine, reducing the temperatures in the NO_x-forming regions. The water can be injected into the fuel, the combustion air or directly into the combustion chamber (ERG, 2000).

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Industrial/Commercial/Institutional (ICI) Boilers," EPA-453/R-94-022, Research Triangle Park, NC, June 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

ERG, 2000: Eastern Research Group, Inc., "How to Incorporate the Effects of Air Pollution Control Device Efficiencies and Malfunctions into Emission Inventory Estimates," prepared for Emission Inventory Improvement Program, Point Sources Committee, July 2000.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: ICI Boilers - Process Gas - Small Sources

Control Measure Name: Selective Catalytic Reduction (SCR)

Rule Name: Not Applicable

Pechan Measure Code: N0414S, N04104

POD: 41

Application: This control is the selective catalytic reduction of NO_x through add-on controls. SCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NO_x) into molecular nitrogen (N₂) and water vapor (H₂O). The SCR utilizes a catalyst to increase the NO_x removal efficiency, which allows the process to occur at lower temperatures.

Applies to small (<1 ton NO_x per OSD) process gas fired ICI boilers with NO_x emissions greater than 10 tons per year.

Affected SCC:

10200701 Industrial, Process Gas, Petroleum Refinery Gas
10200702 Industrial, Process Gas
10200704 Process Gas, Blast Furnace Gas
10200707 Industrial, Process Gas, Coke Oven Gas
10200710 Process Gas, Cogeneration
10200799 Process Gas, Other: Specify in Comments
10201402 CO Boiler, Process Gas
10300701 Commercial/Institutional, Process Gas, POTW Digester Gas-fired Boiler
10300799 Commercial/Institutional, Process Gas, Other Not Classified

Pollutant(s)	PM10	PM2.5	EC	OC	NO _x	VOC	SO ₂	NH ₃	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 80% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NO_x emission levels (Pechan, 1998).

Small source = emission levels less than 1 ton per ozone season day

Costs for stationary source NO_x control are based on an analysis of EPA's NO_x State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 20 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 70% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown for SCR is estimated using information from Appendix E of the ACT document (pages E-53 to E-60). This appendix provides O&M costs for 100, 150, 200, and 250 MMBtu/hour natural gas-

AT-A-GLANCE TABLE FOR POINT SOURCES

fired boilers. The costs by category were averaged for the four boiler sizes to establish a representative O&M cost breakdown for this source category/control measure combination. A capacity factor of 0.5 was used in this evaluation.

Electricity cost: \$0.05/kW-hr

Ammonia cost: \$250/ton

Cost Effectiveness: The cost effectiveness values used in AirControlNET are \$2,230 per ton NO_x reduced from uncontrolled and \$2,860 per ton NO_x reduced from RACT baselines (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

Selective Catalytic Reduction (SCR) has been widely applied to stationary source, fossil fuel-fired, combustion units for emission control since the early 1970s. SCR is typically implemented on units requiring a higher level of NO_x control than achievable by SNCR or other combustion controls (EPA, 2002).

Like SNCR, SCR is based on the chemical reduction of the NO_x molecule. The primary difference between SNCR and SCR is that SCR uses a metal-based catalyst to increase the rate of reaction (EPA, 2002). A nitrogen based reducing reagent, such as ammonia or urea, is injected into the flue gas. The reagent reacts selectively with the flue gas NO_x within a specific temperature range and in the presence of the catalyst and oxygen to reduce the NO_x.

The use of a catalyst results in two advantages of the SCR process over SNCR, the higher NO_x reduction efficiency and the lower and broader temperature ranges. However, the decrease in reaction temperature and increase in efficiency is accompanied by a significant increase in capital and operating costs (EPA, 2002). The cost increase is due to the large amount of catalyst required.

The SCR system can utilize either aqueous or anhydrous ammonia as the reagent. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Today, catalyst formulations include single component, multi-component, or active phase with a support structure. Most catalyst formulations contain additional compounds or supports, providing thermal and structural stability or to increase surface area (EPA, 2002).

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include: reaction temperature range; residence time available in the optimum temperature range; degree of mixing between the injected reagent and the combustion gases; uncontrolled NO_x concentration level; molar ratio of injected reagent to uncontrolled NO_x; ammonia slip; catalyst activity; catalyst selectivity; pressure drop across the catalyst; catalyst pitch; catalyst deactivation; and catalyst management (EPA, 2001).

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Industrial/Commercial/Institutional (ICI) Boilers," EPA-453/R-94-022, Research Triangle Park, NC,

AT-A-GLANCE TABLE FOR POINT SOURCES

June 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: ICI Boilers - Residual Oil - Large Sources

Control Measure Name: Selective Non-Catalytic Reduction (SNCR)

Rule Name: Not Applicable

Pechan Measure Code: N0154L, N01504

POD: 15

Application: This control is the reduction of NO_x emission through selective non-catalytic reduction add-on controls. SNCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NO_x) into molecular nitrogen (N₂) and water vapor (H₂O).

This control applies to large (>1 ton NO_x emissions per OSD) residual oil IC boilers with uncontrolled NO_x emissions greater than 10 tons per year.

Affected SCC:

10200401 Industrial, Residual Oil, Grade 6 Oil
10200402 Residual Oil, 10-100 Million Btu/hr **
10200403 Residual Oil, < 10 Million Btu/hr **
10200404 Industrial, Residual Oil, Grade 5 Oil
10200405 Residual Oil, Cogeneration
10201404 CO Boiler, Residual Oil
10300401 Commercial/Institutional, Residual Oil, Grade 6 Oil
10300402 Commercial/Institutional, Residual Oil, 10-100 Million Btu/hr **
10300404 Commercial/Institutional, Residual Oil, Grade 5 Oil

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 50% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NO_x emission levels (Pechan, 1998).

Large source = emission levels greater than 1 ton per ozone season day

Where information was available in the Alternative Control Techniques (ACT) document (EPA, 1994), capacity-based equations are used to calculate costs. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 20 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 70% (Pechan, 2001).

The following equations, based primarily on information in the Air Pollution Cost Manual (EPA, 2002), are used for large NO_x sources as defined above:

From Uncontrolled:

AT-A-GLANCE TABLE FOR POINT SOURCES

Capital Cost = 62,148.8 * Capacity (MMBtu/hr)^{0.423}

Annual Cost = 2,012.4 * Capacity (MMBtu/hr)^{0.7229}

From RACT Baseline:

Capital Cost = 48,002.6 * Capacity (MMBtu/hr)^{0.423}

Annual Cost = 5,244.4 * Capacity (MMBtu/hr)^{0.4238}

Note: All costs are in 1990 dollars.

O&M Cost Components: The O&M cost breakdown is estimated using the example problem in the OAQPS Control Cost Manual chapter on SNCR. This example was for a 1,000 MMBtu/hr boiler burning sub-bituminous coal.

Electricity cost: \$0.05/kW-hr

Coal cost: \$1.60/MMBtu

Cost Effectiveness: When capacity is available and within the applicable range of 0 to 2,000 MMBTU/hr the cost equations are used to calculate cost effectiveness. The default cost effectiveness value, used when capacity information is not available, is \$1,050 per ton NO_x reduced from uncontrolled and \$560 per ton NO_x reduced from RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

SNCR is the reduction of NO_x in flue gas to N₂ and water vapor. This reduction is done with a nitrogen based reducing reagent, such as ammonia or urea. The reagent can react with a number of flue gas components. However, the NO_x reduction reaction is favored for a specific temperature range and in the presence of oxygen (EPA, 2002).

Both ammonia and urea are used as reagents. The cost of the reagent represents a large part of the annual costs of an SNCR system. Ammonia is generally less expensive than urea. However, the choice of reagent is also based on physical properties and operational considerations (EPA, 2002).

Ammonia can be utilized in either aqueous or anhydrous form. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Urea based systems have several advantages, including several safety aspects. Urea is a nontoxic, less volatile liquid that can be stored and handled more safely than ammonia. Urea solution droplets can penetrate farther into the flue gas when injected into the boiler, enhancing mixing (EPA, 2002). Because of these advantages, urea is more commonly used than ammonia in large boiler applications.

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include:

Reaction temperature range;

AT-A-GLANCE TABLE FOR POINT SOURCES

Residence time available in the optimum temperature range;
Degree of mixing between the injected reagent and the combustion gases
Uncontrolled NO_x concentration level;
Molar ratio of injected reagent to uncontrolled NO_x ; and
Ammonia slip.

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Industrial/Commercial/Institutional (ICI) Boilers," EPA,-453/R-94-022, Research Triangle Park, NC, June 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: ICI Boilers - Residual Oil - Small Sources

Control Measure Name: Low NOx Burner

Rule Name: Not Applicable

Pechan Measure Code: N0151S, N01501

POD: 15

Application: This control is the use of low NOx burner (LNB) technology to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another.

This control is applicable to small (<1 ton NOx per OSD) residual oil-fired ICI boilers with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

10200401 Industrial, Residual Oil, Grade 6 Oil
10200402 Residual Oil, 10-100 Million Btu/hr **
10200403 Residual Oil, < 10 Million Btu/hr **
10200404 Industrial, Residual Oil, Grade 5 Oil
10200405 Residual Oil, Cogeneration
10201404 CO Boiler, Residual Oil
10300401 Commercial/Institutional, Residual Oil, Grade 6 Oil
10300402 Commercial/Institutional, Residual Oil, 10-100 Million Btu/hr **
10300404 Commercial/Institutional, Residual Oil, Grade 5 Oil

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 50% from uncontrolled

Equipment Life: 10 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NOx emission levels (Pechan, 1998).

Small source = emissions level less than 1 ton per ozone season day

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned along with a capital to annual costs ratio of 5.5. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 10 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 70% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown is estimated using the information in the appendix to the 1994 ICI Boiler ACT document. The only O&M cost for LNBs is for administrative, property tax, and insurance, and these are estimated

AT-A-GLANCE TABLE FOR POINT SOURCES

(in total) as 4 percent of the capital investment cost.

Cost Effectiveness: The default cost effectiveness value used in AirControlNET is \$400 per ton NO_x reduced from both uncontrolled and RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNBs create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNBs create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Industrial/Commercial/Institutional (ICI) Boilers," EPA-453/R-94-022, Research Triangle Park, NC, June 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: ICI Boilers - Residual Oil - Small Sources

Control Measure Name: Low NOx Burner + Flue Gas Recirculation

Rule Name: Not Applicable

Pechan Measure Code: N0152S, N01502

POD: 15

Application: This control is the use of low NOx burner (LNB) technology and flue gas recirculation (FGR) to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another.

This control is applicable to small (<1 ton per OSD) residual oil-fired ICI boilers with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

10200401 Industrial, Residual Oil, Grade 6 Oil
10200402 Residual Oil, 10-100 Million Btu/hr **
10200403 Residual Oil, < 10 Million Btu/hr **
10200404 Industrial, Residual Oil, Grade 5 Oil
10200405 Residual Oil, Cogeneration
10201404 CO Boiler, Residual Oil
10300401 Commercial/Institutional, Residual Oil, Grade 6 Oil
10300402 Commercial/Institutional, Residual Oil, 10-100 Million Btu/hr **
10300404 Commercial/Institutional, Residual Oil, Grade 5 Oil

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 60% from uncontrolled

Equipment Life: 10 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by power output (Pechan, 1998).

Small source = less than 1 ton NOx per ozone season day

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). The basis of the costs are model plant data in the Alternative Control Techniques (ACT) document (EPA, 1994). From this analysis, default cost per ton values are assigned along with a capital to annual costs ratio of 5.9. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 10 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 70% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown is estimated using the detailed information in Appendix E of ICI boiler ACT document (see pages E-27 and E-28). A

AT-A-GLANCE TABLE FOR POINT SOURCES

capacity factor of 0.58 is used in estimating the O&M cost breakdown. The model boiler size used to develop cost estimates is 45 MMBtu/hr.

Electricity cost: \$0.05/kW-hr
Natural gas cost: \$3.63/MMBtu

Cost Effectiveness: The default cost effectiveness values are \$1,120 per ton NO_x reduced from uncontrolled and \$1,080 per ton NO_x reduced from RACT (1990\$).

Comments:

Status: Demonstrated	Last Reviewed: 2001
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Additional Information:

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNBs create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNBs create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Industrial/Commercial/Institutional (ICI) Boilers," EPA,-453/R-94-022, Research Triangle Park, NC, June 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: ICI Boilers - Residual Oil - Small Sources

Control Measure Name: Selective Catalytic Reduction (SCR)

Rule Name: Not Applicable

Pechan Measure Code: N0153S, N01503

POD: 15

Application: This control is the selective catalytic reduction of NOx through add-on controls. SCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NOx) into molecular nitrogen (N2) and water vapor (H2O). The SCR utilizes a catalyst to increase the NOx removal efficiency, which allows the process to occur at lower temperatures.

Applies to small (<1 ton NOx per OSD) residual oil-fired ICI boilers with NOx emissions greater than 10 tons per year.

Affected SCC:

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 80% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NOx emission levels (Pechan, 1998).

Small source = emission levels less than 1 ton per ozone season day

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 20 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 70% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown for SCR is estimated using information from Appendix E of the ACT document (pages E-53 to E-60). This appendix provides O&M costs for 100, 150, 200, and 250 MMBtu/hour natural gas-fired boilers. The costs by category were averaged for the four boiler sizes to establish a representative O&M cost breakdown for this source category/control measure combination. A capacity factor of 0.5 was used in this evaluation.

Electricity cost: \$0.05/kW-hr

Ammonia cost: \$250/ton

AT-A-GLANCE TABLE FOR POINT SOURCES

Cost Effectiveness: The cost effectiveness values used in AirControlNET are \$1,480 per ton NO_x reduced from uncontrolled and \$1,910 per ton NO_x reduced from RACT baselines (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

Selective Catalytic Reduction (SCR) has been widely applied to stationary source, fossil fuel-fired, combustion units for emission control since the early 1970s. SCR is typically implemented on units requiring a higher level of NO_x control than achievable by SNCR or other combustion controls (EPA, 2002).

Like SNCR, SCR is based on the chemical reduction of the NO_x molecule. The primary difference between SNCR and SCR is that SCR uses a metal-based catalyst to increase the rate of reaction (EPA, 2002). A nitrogen based reducing reagent, such as ammonia or urea, is injected into the flue gas. The reagent reacts selectively with the flue gas NO_x within a specific temperature range and in the presence of the catalyst and oxygen to reduce the NO_x.

The use of a catalyst results in two advantages of the SCR process over SNCR, the higher NO_x reduction efficiency and the lower and broader temperature ranges. However, the decrease in reaction temperature and increase in efficiency is accompanied by a significant increase in capital and operating costs (EPA, 2002). The cost increase is due to the large amount of catalyst required.

The SCR system can utilize either aqueous or anhydrous ammonia as the reagent. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Today, catalyst formulations include single component, multi-component, or active phase with a support structure. Most catalyst formulations contain additional compounds or supports, providing thermal and structural stability or to increase surface area (EPA, 2002).

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include: reaction temperature range; residence time available in the optimum temperature range; degree of mixing between the injected reagent and the combustion gases; uncontrolled NO_x concentration level; molar ratio of injected reagent to uncontrolled NO_x; ammonia slip; catalyst activity; catalyst selectivity; pressure drop across the catalyst; catalyst pitch; catalyst deactivation; and catalyst management (EPA, 2001).

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Industrial/Commercial/Institutional (ICI) Boilers," EPA-453/R-94-022, Research Triangle Park, NC, June 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity

AT-A-GLANCE TABLE FOR POINT SOURCES

Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: ICI Boilers - Residual Oil - Small Sources

Control Measure Name: Selective Non-Catalytic Reduction (SNCR)

Rule Name: Not Applicable

Pechan Measure Code: N0154S

POD: 15

Application: This control is the reduction of NO_x emission through selective non-catalytic reduction add-on controls. SNCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NO_x) into molecular nitrogen (N₂) and water vapor (H₂O).

This control applies to small (<1 ton NO_x emissions per OSD) residual oil-fired IC boilers with uncontrolled NO_x emissions greater than 10 tons per year.

Affected SCC:

10200401 Industrial, Residual Oil, Grade 6 Oil
10200402 Residual Oil, 10-100 Million Btu/hr **
10200403 Residual Oil, < 10 Million Btu/hr **
10200404 Industrial, Residual Oil, Grade 5 Oil
10200405 Residual Oil, Cogeneration
10201404 CO Boiler, Residual Oil
10300401 Commercial/Institutional, Residual Oil, Grade 6 Oil
10300402 Commercial/Institutional, Residual Oil, 10-100 Million Btu/hr **
10300404 Commercial/Institutional, Residual Oil, Grade 5 Oil

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 50% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NO_x emission levels (Pechan, 1998).

Small source = emission levels less than 1 ton per ozone season day

Costs for stationary source NO_x control are based on an analysis of EPA's NO_x State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned for small sources. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 20 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 70% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown is estimated using the example problem in the OAQPS Control Cost Manual chapter on SNCR. This example was for a 1,000 MMBtu/hr boiler burning sub-bituminous coal.

AT-A-GLANCE TABLE FOR POINT SOURCES

Electricity cost: \$0.05/kW-hr

Coal cost: \$1.60/MMBtu

Cost Effectiveness: The cost effectiveness values used in AirControlNET are \$2,580 per ton NOx reduced from uncontrolled and \$ 1,940 per ton NOx reduced from RACT baseline (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

SNCR is the reduction of NOx in flue gas to N2 and water vapor. This reduction is done with a nitrogen based reducing reagent, such as ammonia or urea. The reagent can react with a number of flue gas components. However, the NOx reduction reaction is favored for a specific temperature range and in the presence of oxygen (EPA, 2002).

Both ammonia and urea are used as reagents. The cost of the reagent represents a large part of the annual costs of an SNCR system. Ammonia is generally less expensive than urea. However, the choice of reagent is also based on physical properties and operational considerations (EPA, 2002).

Ammonia can be utilized in either aqueous or anhydrous form. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Urea based systems have several advantages, including several safety aspects. Urea is a nontoxic, less volatile liquid that can be stored and handled more safely than ammonia. Urea solution droplets can penetrate farther into the flue gas when injected into the boiler, enhancing mixing (EPA, 2002). Because of these advantages, urea is more commonly used than ammonia in large boiler applications.

The rate of reaction determines the amount of NOx removed from the flue gas. The important design and operational factors that affect the rate of reduction include:

Reaction temperature range;

Residence time available in the optimum temperature range;

Degree of mixing between the injected reagent and the combustion gases

Uncontrolled NOx concentration level;

Molar ratio of injected reagent to uncontrolled NOx ; and ammonia slip.

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Industrial/Commercial/Institutional (ICI) Boilers," EPA,-453/R-94-022, Research Triangle Park, NC, June 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity

AT-A-GLANCE TABLE FOR POINT SOURCES

Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: ICI Boilers - Wood/Bark/Stoker - Large Sources

Control Measure Name: Selective Non-Catalytic Reduction (SNCR) Urea Based

Rule Name: Not Applicable

Pechan Measure Code: N0181L, N01801

POD: 18

Application: This control is the reduction of NO_x emission through urea based selective non-catalytic reduction add-on controls. SNCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NO_x) into molecular nitrogen (N₂) and water vapor (H₂O).

This control applies to large(>1 ton NO_x emissions per OSD) wood/bark fired IC boilers with uncontrolled NO_x emissions greater than 10 tons per year.

Affected SCC:

10200901 Industrial, Wood/Bark Waste, Bark-fired Boiler (> 50,000 Lb Steam)
10200902 Industrial, Wood/Bark Waste, Wood/Bark-fired Boiler (> 50,000 Lb Steam)
10200903 Industrial, Wood/Bark Waste, Wood-fired Boiler (> 50,000 Lb Steam)
10200904 Wood/Bark Waste, Bark-fired Boiler (< 50,000 Lb Steam)
10200905 Wood/Bark Waste, Wood/Bark-fired Boiler (< 50,000 Lb Steam)
10200906 Industrial, Wood/Bark Waste, Wood-fired Boiler (< 50,000 Lb Steam)
10200907 Wood/Bark Waste, Wood Cogeneration
10300902 Wood/Bark Waste, Wood/Bark-fired Boiler
10300903 Commercial/Institutional, Wood/Bark Waste, Wood-fired Boiler

Pollutant(s)	PM10	PM2.5	EC	OC	NO _x	VOC	SO ₂	NH ₃	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 55% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NO_x emission levels (Pechan, 1998).

Large source = emission levels greater than 1 ton per ozone season day

Where information was available in the Alternative Control Techniques (ACT) document (EPA, 1994), capacity-based equations are used to calculate costs. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 20 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 70% (Pechan, 2001).

The following equations, based primarily on information in the Air Pollution Cost Manual (EPA, 2002), are used for large NO_x sources as defined above:

From Uncontrolled:

AT-A-GLANCE TABLE FOR POINT SOURCES

Capital Cost = $65,820.1 * \text{Capacity (MMBtu/hr)}^{0.3607}$

Annual Cost = $17,777.1 * \text{Capacity (MMBtu/hr)}^{0.3462}$

From RACT Baseline:

Capital Cost = $65,820.1 * \text{Capacity (MMBtu/hr)}^{0.361}$

Annual Cost = $17,777.1 * \text{Capacity (MMBtu/hr)}^{0.3462}$

Note: All costs are in 1990 dollars.

O&M Cost Components: The O&M cost breakdown is estimated using the example problem in the OAQPS Control Cost Manual chapter on SNCR. This example was for a 1,000 MMBtu/hr boiler burning sub-bituminous coal.

Electricity cost: \$0.05/kW-hr

Coal cost: \$1.60/MMBtu

Cost Effectiveness: When capacity is available and within the applicable range of 0 to 2,000 MMBTU/hr the cost equations are used to calculate cost effectiveness. The default cost effectiveness values, used when capacity information is not available, is \$1,190 per ton NO_x reduced from both uncontrolled and RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

SNCR is the reduction of NO_x in flue gas to N₂ and water vapor. This reduction is done with a nitrogen based reducing reagent, such as ammonia or urea. The reagent can react with a number of flue gas components. However, the NO_x reduction reaction is favored for a specific temperature range and in the presence of oxygen (EPA, 2002).

Urea based systems have several advantages, including several safety aspects. Urea is a nontoxic, less volatile liquid that can be stored and handled more safely than ammonia. Urea solution droplets can penetrate farther into the flue gas when injected into the boiler, enhancing mixing (EPA, 2002). Because of these advantages, urea is more commonly used than ammonia in large boiler applications.

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include:

Reaction temperature range;

Residence time available in the optimum temperature range;

Degree of mixing between the injected reagent and the combustion gases

Uncontrolled NO_x concentration level;

Molar ratio of injected reagent to uncontrolled NO_x ; and ammonia slip.

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Industrial/Commercial/Institutional (ICI) Boilers," EPA-453/R-94-022, Research Triangle Park, NC,

AT-A-GLANCE TABLE FOR POINT SOURCES

June 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: ICI Boilers - Wood/Bark/Stoker - Small Sources

Control Measure Name: Selective Non-Catalytic Reduction (SNCR) Urea Based

Rule Name: Not Applicable

Pechan Measure Code: N0181S

POD: 18

Application: This control is the reduction of NO_x emission through urea based selective non-catalytic reduction add-on controls. SNCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NO_x) into molecular nitrogen (N₂) and water vapor (H₂O).

This control applies to small (<1 ton NO_x emissions per OSD) wood/bark fired IC boilers with uncontrolled NO_x emissions greater than 10 tons per year.

Affected SCC:

10200901 Industrial, Wood/Bark Waste, Bark-fired Boiler (> 50,000 Lb Steam)
10200902 Industrial, Wood/Bark Waste, Wood/Bark-fired Boiler (> 50,000 Lb Steam)
10200903 Industrial, Wood/Bark Waste, Wood-fired Boiler (> 50,000 Lb Steam)
10200904 Wood/Bark Waste, Bark-fired Boiler (< 50,000 Lb Steam)
10200905 Wood/Bark Waste, Wood/Bark-fired Boiler (< 50,000 Lb Steam)
10200906 Industrial, Wood/Bark Waste, Wood-fired Boiler (< 50,000 Lb Steam)
10200907 Wood/Bark Waste, Wood Cogeneration
10300902 Wood/Bark Waste, Wood/Bark-fired Boiler
10300903 Commercial/Institutional, Wood/Bark Waste, Wood-fired Boiler

Pollutant(s)	PM10	PM2.5	EC	OC	NO _x	VOC	SO ₂	NH ₃	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 55% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NO_x emission levels (Pechan, 1998).

Small source = emission levels less than 1 ton per ozone season day

Costs for stationary source NO_x control are based on an analysis of EPA's NO_x State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned for small sources. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 20 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 70% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown is estimated using the example problem in the OAQPS Control Cost Manual chapter on SNCR. This example was for a 1,000 MMBtu/hr boiler burning sub-bituminous coal.

AT-A-GLANCE TABLE FOR POINT SOURCES

Electricity cost: \$0.05/kW-hr

Coal cost: \$1.60/MMBtu

Cost Effectiveness: The cost effectiveness used in AirControlNET for both reductions from baseline and reductions from RACT is \$1,440 per ton NO_x reduced (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

SNCR is the reduction of NO_x in flue gas to N₂ and water vapor. This reduction is done with a nitrogen based reducing reagent, such as ammonia or urea. The reagent can react with a number of flue gas components. However, the NO_x reduction reaction is favored for a specific temperature range and in the presence of oxygen (EPA, 2002).

Both ammonia and urea are used as reagents. The cost of the reagent represents a large part of the annual costs of an SNCR system. Ammonia is generally less expensive than urea. However, the choice of reagent is also based on physical properties and operational considerations (EPA, 2002).

Ammonia can be utilized in either aqueous or anhydrous form. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Urea based systems have several advantages, including several safety aspects. Urea is a nontoxic, less volatile liquid that can be stored and handled more safely than ammonia. Urea solution droplets can penetrate farther into the flue gas when injected into the boiler, enhancing mixing (EPA, 2002). Because of these advantages, urea is more commonly used than ammonia in large boiler applications.

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include:

Reaction temperature range;

Residence time available in the optimum temperature range;

Degree of mixing between the injected reagent and the combustion gases

Uncontrolled NO_x concentration level;

Molar ratio of injected reagent to uncontrolled NO_x ; and ammonia slip.

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Industrial/Commercial/Institutional (ICI) Boilers," EPA,-453/R-94-022, Research Triangle Park, NC, June 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air

AT-A-GLANCE TABLE FOR POINT SOURCES

Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Industrial Coal Combustion

Control Measure Name: RACT to 50 tpy (LNB)

Rule Name: Reasonably Available Control Technology - 50 tpy

Pechan Measure Code: N10001

POD: 100

Application: The RACT control technology used is the addition of a low NOx burner to reduce NOx emissions.

This standard applies to sources with boilers fueled by coal that emit over 50 tpy NOx (classified under SCCs 2102001000 and 2102002000).

Affected SCC:

2102001000 Anthracite Coal, Total: All Boiler Types

2102002000 Bituminous/Subbituminous Coal, Total: All Boiler Types

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√/*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 21% from uncontrolled

Equipment Life: 10 years

Rule Effectiveness: 80%

Penetration: 23%

Cost Basis: Cost per ton (CPT) values are based on applying the cost equations developed for the point source ICI boilers to small sources. For coal, costs are based on a 50 MMBtu/hr boiler operating at 33% capacity. Costs are based on a 10-year equipment life and a 5% discount rate (Pechan, 1998).

Annual Cost (AC) = CPT * Emissions *(Control Efficiency *Rule Effectiveness*Rule Penetration)

Cost Effectiveness = AC / Tons NOx Reduced Per Year

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$1,350 per ton NOx reduced (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 1998

Additional Information:

References:

Pechan, 1996: E.H. Pechan & Associates, "The Emission Reduction and Cost Analysis Model for NOx (ECRAM-NOx)," Revised Documentation, prepared for U.S. Environmental Protection Agency, Ozone Policy and Strategies Group, Research Triangle Park, NC, September 1996.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Clean Air Act Section 812 Prospective Cost Analysis - Draft Report," prepared for Industrial Economics, Inc., Cambridge, MA, September 1998.

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Industrial Coal Combustion

Control Measure Name: RACT to 25 tpy (LNB)

Rule Name: Reasonably Available Control Technology - 25 tpy

Pechan Measure Code: N10002

POD: 100

Application: The RACT control technology used is the addition of a low NOx burner to reduce NOx emissions.

This standard applies to sources with boilers fueled by coal that emit over 25 tpy NOx (classified under SCCs 2102001000 and 2102002000).

Affected SCC:

2102001000 Anthracite Coal, Total: All Boiler Types

2102002000 Bituminous/Subbituminous Coal, Total: All Boiler Types

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√/*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 21% from uncontrolled

Equipment Life: 10 years

Rule Effectiveness: 80%

Penetration: 45%

Cost Basis: Cost per ton (CPT) values are based on applying the cost equations developed for the point source ICI boilers to small sources. For coal, costs are based on a 50 MMBtu/hr boiler operating at 33% capacity. Costs are based on a 10-year equipment life and a 5% discount rate (Pechan, 1998).

Annual Cost (AC) = CPT * Emissions *(Control Efficiency *Rule Effectiveness*Rule Penetration)

Cost Effectiveness = AC / Tons NOx Reduced Per Year

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$1,350 per ton NOx reduced (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 1998

Additional Information:

References:

Pechan, 1996: E.H. Pechan & Associates, "The Emission Reduction and Cost Analysis Model for NOx (ECRAM-NOx)," Revised Documentation, prepared for U.S. Environmental Protection Agency, Ozone Policy and Strategies Group, Research Triangle Park, NC, September 1996.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Clean Air Act Section 812 Prospective Cost Analysis - Draft Report," prepared for Industrial Economics, Inc., Cambridge, MA, September 1998.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Industrial Incinerators

Control Measure Name: Selective Non-Catalytic Reduction (SNCR)

Rule Name: Not Applicable

Pechan Measure Code: N0601S, N06001

POD: 60

Application: This control is the reduction of NO_x emission through selective non-catalytic reduction add-on controls. SNCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NO_x) into molecular nitrogen (N₂) and water vapor (H₂O).

This control applies to industrial incinerators IC boilers with uncontrolled NO_x emissions greater than 10 tons per year.

Affected SCC:

30190012 Fuel Fired Equipment, Residual Oil: Incinerators
30190013 Fuel Fired Equipment, Natural Gas: Incinerators
30190014 Fuel Fired Equipment, Process Gas: Incinerators
30590013 Fuel Fired Equipment, Natural Gas: Incinerators
30790013 Fuel Fired Equipment, Natural Gas: Incinerators
30890013 Fuel Fired Equipment, Natural Gas: Incinerators
39990013 Miscellaneous Manufacturing Industries, Natural Gas: Incinerators
50300101 Solid Waste Disposal - Industrial, Incineration, Multiple Chamber
50300102 Solid Waste Disposal - Industrial, Incineration, Single Chamber
50300103 Solid Waste Disposal - Industrial, Incineration, Controlled Air
50300104 Incineration, Conical Design (Tee Pee) Municipal Refuse
50300105 Solid Waste Disposal - Industrial, Incineration, Conical Design (Tee Pee) Wood Refuse
50300506 Solid Waste Disposal - Industrial, Incineration, Sludge

Pollutant(s)	PM10	PM2.5	EC	OC	NO _x	VOC	SO ₂	NH ₃	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 45% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NO_x emission levels (Pechan, 1998).

Small source = emission levels less than 1 ton per ozone season day
Large source = emission levels greater than 1 ton per ozone season day

Costs for stationary source NO_x control are based on an analysis of EPA's NO_x State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned for small sources. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 20 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing

AT-A-GLANCE TABLE FOR POINT SOURCES

controls (RACT baseline), with efficiencies less than 70% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown is estimated using the information in Chapter and Appendix A of the MWC ACT document. The cost outputs for conventional SNCR applied to the 400 ton per day model combustor (Table 3-3) are used to estimate the O&M cost breakdown. The tipping fee (\$1.47 per ton) is included as a waste disposal cost (direct annual cost).

Electricity Cost: 0.046 \$/kW-hr

Cost Effectiveness: The cost effectiveness (for both small and large sources) used in AirControlNET for both reductions from baseline and reductions from RACT is \$1,130 per ton NO_x reduced (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

SNCR is the reduction of NO_x in flue gas to N₂ and water vapor. This reduction is done with a nitrogen based reducing reagent, such as ammonia or urea. The reagent can react with a number of flue gas components. However, the NO_x reduction reaction is favored for a specific temperature range and in the presence of oxygen (EPA, 2002).

Both ammonia and urea are used as reagents. The cost of the reagent represents a large part of the annual costs of an SNCR system. Ammonia is generally less expensive than urea. However, the choice of reagent is also based on physical properties and operational considerations (EPA, 2002).

Ammonia can be utilized in either aqueous or anhydrous form. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Urea based systems have several advantages, including several safety aspects. Urea is a nontoxic, less volatile liquid that can be stored and handled more safely than ammonia. Urea solution droplets can penetrate farther into the flue gas when injected into the boiler, enhancing mixing (EPA, 2002). Because of these advantages, urea is more commonly used than ammonia in large boiler applications.

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include:

Reaction temperature range;
Residence time available in the optimum temperature range;
Degree of mixing between the injected reagent and the combustion gases
Uncontrolled NO_x concentration level;
Molar ratio of injected reagent to uncontrolled NO_x ; and
Ammonia slip.

References:

EPA, 1994: U.S. Environmental Protection Agency, Radian Corporation, "Alternative Control Techniques Document-- NO_x Emissions from Municipal Waste Combustion," EPA-600/R-94-208, Research Triangle Park, NC, December, 1994.

AT-A-GLANCE TABLE FOR POINT SOURCES

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Industrial Natural Gas Combustion

Control Measure Name: RACT to 50 tpy (LNB)

Rule Name: Reasonably Available Control Technology - 50 tpy

Pechan Measure Code: N10201

POD: 102

Application: The RACT control technology used is the addition of a low NOx burner to reduce NOx emissions.

This standard applies to sources with boilers fueled by coal that emit over 50 tpy NOx (classified under SCCs 2102001000 and 2102002000).

Affected SCC:

2102006000 Natural Gas, Total: Boilers and IC Engines

2102006002 Natural Gas, All IC Engine Types

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√/*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 31% from uncontrolled

Equipment Life: 10 years

Rule Effectiveness: 80%

Penetration: 11%

Cost Basis: Cost per ton (CPT) values are based on applying the cost equations developed for the point source ICI boilers to small sources. For gas and oil, costs are based on a 25 MMBtu/hour boiler operating at 33 percent of capacity, an equipment lifetime of 10 years, and a 5 percent discount rate (Pechan, 1998).

Annual Cost (AC) = CPT * Emissions *(Control Efficiency *Rule Effectiveness*Rule Penetration)

Cost Effectiveness = AC / Tons NOx Reduced Per Year

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$770 per ton NOx reduced (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 1998

Additional Information:

References:

Pechan, 1996: E.H. Pechan & Associates, "The Emission Reduction and Cost Analysis Model for NOx (ECRAM-NOx)," Revised Documentation, prepared for U.S. Environmental Protection Agency, Ozone Policy and Strategies Group, Research Triangle Park, NC, September 1996.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Clean Air Act Section 812 Prospective Cost Analysis - Draft Report," prepared for Industrial Economics, Inc., Cambridge, MA, September 1998.

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Industrial Natural Gas Combustion

Control Measure Name: RACT to 25 tpy (LNB)

Rule Name: Reasonably Available Control Technology - 25 tpy

Pechan Measure Code: N10202

POD: 102

Application: The RACT control technology used is the addition of a low NOx burner to reduce NOx emissions.

This standard applies to sources with boilers fueled by coal that emit over 50 tpy NOx (classified under SCCs 2102001000 and 2102002000).

Affected SCC:

2102006000 Natural Gas, Total: Boilers and IC Engines

2102006002 Natural Gas, All IC Engine Types

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√/*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 31% from uncontrolled

Equipment Life: 10 years

Rule Effectiveness: 80%

Penetration: 22%

Cost Basis: Cost per ton (CPT) values are based on applying the cost equations developed for the point source ICI boilers to small sources. For gas and oil, costs are based on a 25 MMBtu/hour boiler operating at 33 percent of capacity, an equipment lifetime of 10 years, and a 5 percent discount rate (Pechan, 1998).

Annual Cost (AC) = CPT * Emissions *(Control Efficiency *Rule Effectiveness*Rule Penetration)

Cost Effectiveness = AC / Tons NOx Reduced Per Year

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$770 per ton NOx reduced (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 1998

Additional Information:

References:

Pechan, 1996: E.H. Pechan & Associates, "The Emission Reduction and Cost Analysis Model for NOx (ECRAM-NOx)," Revised Documentation, prepared for U.S. Environmental Protection Agency, Ozone Policy and Strategies Group, Research Triangle Park, NC, September 1996.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Clean Air Act Section 812 Prospective Cost Analysis - Draft Report," prepared for Industrial Economics, Inc., Cambridge, MA, September 1998.

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Industrial Oil Combustion

Control Measure Name: RACT to 50 tpy (LNB)

Rule Name: Reasonably Available Control Technology - 50 tpy

Pechan Measure Code: N10101

POD: 101

Application: The RACT control technology used is the addition of a low NOx burner to reduce NOx emissions.

This standard applies to sources with boilers fueled by coal that emit over 50 tpy NOx (classified under SCCs 2102001000 and 2102002000).

Affected SCC:

2102004000 Distillate Oil, Total: Boilers and IC Engines

2102005000 Residual Oil, Total: All Boiler Types

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√/*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 36% from uncontrolled

Equipment Life: 10 years

Rule Effectiveness: 80%

Penetration: 8%

Cost Basis: Cost per ton (CPT) values are based on applying the cost equations developed for the point source ICI boilers to small sources. For gas and oil, costs are based on a 25 MMBtu/hour boiler operating at 33 percent of capacity, an equipment lifetime of 10 years, and a 5 percent discount rate (Pechan, 1998).

Annual Cost (AC) = CPT * Emissions *(Control Efficiency *Rule Effectiveness*Rule Penetration)

Cost Effectiveness = AC / Tons NOx Reduced Per Year

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$1,180 per ton NOx reduced (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 1998

Additional Information:

References:

Pechan, 1996: E.H. Pechan & Associates, "The Emission Reduction and Cost Analysis Model for NOx (ECRAM-NOx)," Revised Documentation, prepared for U.S. Environmental Protection Agency, Ozone Policy and Strategies Group, Research Triangle Park, NC, September 1996.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Clean Air Act Section 812 Prospective Cost Analysis - Draft Report," prepared for Industrial Economics, Inc., Cambridge, MA, September 1998.

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Industrial Oil Combustion

Control Measure Name: RACT to 25 tpy (LNB)

Rule Name: Reasonably Available Control Technology - 25 tpy

Pechan Measure Code: N10102

POD: 101

Application: The RACT control technology used is the addition of a low NOx burner to reduce NOx emissions.

This standard applies to sources with boilers fueled by coal that emit over 25 tpy NOx (classified under SCCs 2102001000 and 2102002000).

Affected SCC:

2102004000 Distillate Oil, Total: Boilers and IC Engines

2102005000 Residual Oil, Total: All Boiler Types

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√/*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 36% from uncontrolled

Equipment Life: 10 years

Rule Effectiveness: 80%

Penetration: 16%

Cost Basis: Cost per ton (CPT) values are based on applying the cost equations developed for the point source ICI boilers to small sources. For gas and oil, costs are based on a 25 MMBtu/hour boiler operating at 33 percent of capacity, an equipment lifetime of 10 years, and a 5 percent discount rate (Pechan, 1998).

Annual Cost (AC) = CPT * Emissions *(Control Efficiency *Rule Effectiveness*Rule Penetration)

Cost Effectiveness = AC / Tons NOx Reduced Per Year

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$1,180 per ton NOx reduced (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 1998

Additional Information:

References:

Pechan, 1996: E.H. Pechan & Associates, "The Emission Reduction and Cost Analysis Model for NOx (ECRAM-NOx)," Revised Documentation, prepared for U.S. Environmental Protection Agency, Ozone Policy and Strategies Group, Research Triangle Park, NC, September 1996.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Clean Air Act Section 812 Prospective Cost Analysis - Draft Report," prepared for Industrial Economics, Inc., Cambridge, MA, September 1998.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: In-Proc; Process Gas; Coke Oven/Blast Ovens

Control Measure Name: Low NOx Burner + Flue Gas Recirculation

Rule Name: Not Applicable

Pechan Measure Code: N0862S, N08602

POD: 86

Application: This control is the use of low NOx burner (LNB) technology and flue gas recirculation (FGR) to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another.

This control is applicable to small (<1 ton per OSD) sources with in-process coke/blast furnaces and uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

39000701 In-process Fuel Use, Process Gas, Coke Oven or Blast Furnace

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 55% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by power output (Pechan, 1998).

Small source = less than 1 ton NOx per ozone season day

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). The basis of the costs are model plant data in the Alternative Control Techniques (ACT) document (EPA, 1993). From this analysis, default cost per ton values are assigned along with a capital to annual costs ratio of 6.9. A discount rate of 10 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 15 years (EPA, 1993).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 70% (Pechan, 2001).

Cost Effectiveness: The default cost effectiveness values are \$3,190 per ton NOx reduced from uncontrolled and \$1,430 per ton NOx reduced from RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNBs create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNBs create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

References:

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Process Heaters," EPA-453/R-93-034, Research Triangle Park, NC, September 1993.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: In-Process Fuel Use - Bituminous Coal - Small Sources

Control Measure Name: Selective Non-Catalytic Reduction (SNCR)

Rule Name: Not Applicable

Pechan Measure Code: N0831S, N08301

POD: 83

Application: This control is the reduction of NOx emission through selective non-catalytic reduction add-on controls. SNCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NOx) into molecular nitrogen (N2) and water vapor (H2O).

This control applies to small (<1 ton NOx emissions per OSD) operations with general (in process) bituminous coal use and uncontrolled NOx emissions greater than 10 tons per year. These sources are classified under SCC 39000289.

Affected SCC:

39000289 Bituminous Coal, General (Bituminous)

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 40% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NOx emission levels (Pechan, 1998).

Small source = emission levels less than 1 ton per ozone season day

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned for small sources. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 20 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than 70% (Pechan, 2001).

Cost Effectiveness: The cost effectiveness used in AirControlNET for both reductions from baseline and reductions from RACT is \$1,260 per ton NOx reduced (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

SNCR is the reduction of NO_x in flue gas to N₂ and water vapor. This reduction is done with a nitrogen based reducing reagent, such as ammonia or urea. The reagent can react with a number of flue gas components. However, the NO_x reduction reaction is favored for a specific temperature range and in the presence of oxygen (EPA, 2002).

Both ammonia and urea are used as reagents. The cost of the reagent represents a large part of the annual costs of an SNCR system. Ammonia is generally less expensive than urea. However, the choice of reagent is also based on physical properties and operational considerations (EPA, 2002).

Ammonia can be utilized in either aqueous or anhydrous form. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Urea based systems have several advantages, including several safety aspects. Urea is a nontoxic, less volatile liquid that can be stored and handled more safely than ammonia. Urea solution droplets can penetrate farther into the flue gas when injected into the boiler, enhancing mixing (EPA, 2002). Because of these advantages, urea is more commonly used than ammonia in large boiler applications.

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include:

Reaction temperature range;
Residence time available in the optimum temperature range;
Degree of mixing between the injected reagent and the combustion gases
Uncontrolled NO_x concentration level;
Molar ratio of injected reagent to uncontrolled NO_x ; and
Ammonia slip.

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Industrial/Commercial/Institutional (ICI) Boilers," EPA-453/R-94-022, Research Triangle Park, NC, June 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: In-Process Fuel Use; Natural Gas - Small Sources

Control Measure Name: Low NOx Burner

Rule Name: Not Applicable

Pechan Measure Code: N0851S, N08501

POD: 85

Application: This control is the use of low NOx burner (LNB) technology to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another.

This control is applicable to small (<1 ton NOx per OSD) operations with in-process natural gas usage and uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

39000689 In-process Fuel Use, Natural Gas, General

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 50% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NOx emission levels (Pechan, 1998).

Small source = emissions level less than 1 ton per ozone season day

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned along with a capital to annual costs ratio of 7.3. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 15 years (EPA, 1994).

Cost Effectiveness: The default cost effectiveness value used in AirControlNET is \$2,200 per ton NOx reduced from both uncontrolled and RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 1998

Additional Information:

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNBs create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNBs create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

AT-A-GLANCE TABLE FOR POINT SOURCES

References:

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Process Heaters," EPA,-453/R-93-034, Research Triangle Park, NC, September 1993.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: In-Process Fuel Use; Residual Oil - Small Sources

Control Measure Name: Low NOx Burner

Rule Name: Not Applicable

Pechan Measure Code: N0842S, N08402

POD: 84

Application: This control is the use of low NOx burner (LNB) technology to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another.

This control is applicable to small (<1 ton NOx per OSD) operations with in-process residual oil usage and uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

39000489 In-process Fuel Use, Residual Oil, General

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 37% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NOx emission levels (Pechan, 1998).

Small source = emissions level less than 1 ton per ozone season day

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned along with a capital to annual costs ratio of 7.3. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 15 years (EPA, 1994).

Cost Effectiveness: The default cost effectiveness value used in AirControlNET is \$2,250 per ton NOx reduced from both uncontrolled and RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 1998

Additional Information:

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNBs create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNBs create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

AT-A-GLANCE TABLE FOR POINT SOURCES

References:

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Process Heaters," EPA,-453/R-93-034, Research Triangle Park, NC, September 1993.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: In-Process; Bituminous Coal; Cement Kilns

Control Measure Name: Selective Non-Catalytic Reduction (SNCR) Urea Based

Rule Name: Not Applicable

Pechan Measure Code: N0813S, N08103

POD: 81

Application: This control is the reduction of NO_x emission through selective non-catalytic reduction add-on controls. SNCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NO_x) into molecular nitrogen (N₂) and water vapor (H₂O).

This control applies to bituminous coal-fired cement kilns (SCC 39000201) with uncontrolled NO_x emissions greater than 10 tons per year.

Affected SCC:

39000201 Bituminous Coal, Cement Kiln/Dryer (Bituminous Coal)

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 50% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NO_x emission levels (Pechan, 1998).

Small source = emission levels less than 1 ton per ozone season day

Large source = emission levels greater than 1 ton per ozone season day

Costs for stationary source NO_x control are based on an analysis of EPA's NO_x State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned for small sources. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 15 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than 70% (Pechan, 2001).

Cost Effectiveness: The cost effectiveness (for both small and large sources) used in AirControlNET for both reductions from baseline and reductions from RACT is \$770 per ton NO_x reduced (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

SNCR is the reduction of NO_x in flue gas to N₂ and water vapor. This reduction is done with a nitrogen based reducing reagent, such as ammonia or urea. The reagent can react with a number of flue gas components. However, the NO_x reduction reaction is favored for a specific temperature range and in the presence of oxygen (EPA, 2002).

Both ammonia and urea are used as reagents. The cost of the reagent represents a large part of the annual costs of an SNCR system. Ammonia is generally less expensive than urea. However, the choice of reagent is also based on physical properties and operational considerations (EPA, 2002).

Ammonia can be utilized in either aqueous or anhydrous form. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Urea based systems have several advantages, including several safety aspects. Urea is a nontoxic, less volatile liquid that can be stored and handled more safely than ammonia. Urea solution droplets can penetrate farther into the flue gas when injected into the boiler, enhancing mixing (EPA, 2002). Because of these advantages, urea is more commonly used than ammonia in large boiler applications.

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include:

Reaction temperature range;
Residence time available in the optimum temperature range;
Degree of mixing between the injected reagent and the combustion gases
Uncontrolled NO_x concentration level;
Molar ratio of injected reagent to uncontrolled NO_x ; and
Ammonia slip.

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Cement Manufacturing," EPA-453/R-94-004, Research Triangle Park, NC, March, 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: In-Process; Bituminous Coal; Lime Kilns

Control Measure Name: Selective Non-Catalytic Reduction (SNCR) Urea Based

Rule Name: Not Applicable

Pechan Measure Code: N0823S, N08203

POD: 82

Application: This control is the reduction of NO_x emission through selective non-catalytic reduction add-on controls. SNCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NO_x) into molecular nitrogen (N₂) and water vapor (H₂O).

This control applies to bituminous coal-fired lime kilns (SCC 39000203) with uncontrolled NO_x emissions greater than 10 tons per year.

Affected SCC:

39000203 In-process Fuel Use, Bituminous Coal, Lime Kiln (Bituminous)

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 50% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NO_x emission levels (Pechan, 1998).

Small source = emission levels less than 1 ton per ozone season day

Large source = emission levels greater than 1 ton per ozone season day

Costs for stationary source NO_x control are based on an analysis of EPA's NO_x State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned for small sources. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 15 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than 70% (Pechan, 2001).

Cost Effectiveness: The cost effectiveness (for both small and large sources) used in AirControlNET for both reductions from baseline and reductions from RACT is \$770 per ton NO_x reduced (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

SNCR is the reduction of NO_x in flue gas to N₂ and water vapor. This reduction is done with a nitrogen based reducing reagent, such as ammonia or urea. The reagent can react with a number of flue gas components. However, the NO_x reduction reaction is favored for a specific temperature range and in the presence of oxygen (EPA, 2002).

Both ammonia and urea are used as reagents. The cost of the reagent represents a large part of the annual costs of an SNCR system. Ammonia is generally less expensive than urea. However, the choice of reagent is also based on physical properties and operational considerations (EPA, 2002).

Ammonia can be utilized in either aqueous or anhydrous form. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Urea based systems have several advantages, including several safety aspects. Urea is a nontoxic, less volatile liquid that can be stored and handled more safely than ammonia. Urea solution droplets can penetrate farther into the flue gas when injected into the boiler, enhancing mixing (EPA, 2002). Because of these advantages, urea is more commonly used than ammonia in large boiler applications.

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include:

Reaction temperature range;
Residence time available in the optimum temperature range;
Degree of mixing between the injected reagent and the combustion gases
Uncontrolled NO_x concentration level;
Molar ratio of injected reagent to uncontrolled NO_x ; and
Ammonia slip.

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Cement Manufacturing," EPA-453/R-94-004, Research Triangle Park, NC, March, 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: In-Process; Process Gas; Coke Oven Gas

Control Measure Name: Low NOx Burner

Rule Name: Not Applicable

Pechan Measure Code: N0871S, N08701

POD: 87

Application: This control is the use of low NOx burner (LNB) technology to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another.

This control is applicable to small (<1 ton NOx per OSD) operations with in-process coke oven gas usage and uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

39000789 Process Gas, Coke Oven Gas

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 50%from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NOx emission levels (Pechan, 1998).

Small source = emissions level less than 1 ton per ozone season day

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned along with a capital to annual costs ratio of 7.3. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 15 years (EPA, 1994).

Cost Effectiveness: The default cost effectiveness value used in AirControlNET is \$2,200 per ton NOx reduced from both uncontrolled and RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 1998

Additional Information:

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNBs create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNBs create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

AT-A-GLANCE TABLE FOR POINT SOURCES

References:

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Process Heaters," EPA,-453/R-93-034, Research Triangle Park, NC, September 1993.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Internal Combustion Engines - Gas

Control Measure Name: L-E (Medium Speed)

Rule Name: Not Applicable

Pechan Measure Code: N02210

POD: 22

Application: This control is the application of L-E (Medium Speed) technology to reduce NOx emissions.

This control applies to gasoline powered IC engines with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

20200202 Industrial, Natural Gas, Reciprocating
20200204 Natural Gas, Reciprocating: Cogeneration
20300201 Natural Gas, Reciprocating
20300204 Natural Gas, Cogeneration

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 87% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 25% (Pechan, 2001).

Cost Effectiveness: The default cost effectiveness value is \$380 per ton NOx reduced from both uncontrolled and RACT baselines (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

References:

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Stationary Reciprocating Internal Combustion Engines," EPA,-453/R-93-032, Research Triangle Park, NC, July 1993

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection

AT-A-GLANCE TABLE FOR POINT SOURCES

Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.8.
.EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Stationary Reciprocating Internal Combustion Engines," EPA,-453/R-93-032, Research Triangle Park, NC, July 1993

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.8.
.EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Stationary Reciprocating Internal Combustion Engines," EPA,-453/R-93-032, Research Triangle Park, NC, July 1993

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.8.

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AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Internal Combustion Engines - Gas - Large Sources

Control Measure Name: Ignition Retard

Rule Name: Not Applicable

Pechan Measure Code: N0221L

POD: 22

Application: This control is the use of ignition retard technologies to reduce NOx emissions.

This applies to large (>4,000 HP) gasoline powered IC engines with uncontrolled NOx emissions greater than 10 tons per yea

Affected SCC:

20200202 Industrial, Natural Gas, Reciprocating

20300201 Natural Gas, Reciprocating

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√/*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 20% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by power (Pechan, 1998).

Engines greater than 4,000 horsepower were considered large engines.

Capital and annual cost information was obtained from model engine data in the Alternative Control Techniques (ACT) document (EPA, 1993). A capital cost to annual cost ratio of 0.7 was developed to estimate default capital and operating and maintenance costs. From these determinations, default cost effectiveness values were assigned. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 15 years (EPA, 1993).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 25% (Pechan, 2001).

Cost Effectiveness: The default cost effectiveness value is \$550 per ton NOx reduced from both uncontrolled RACT baselines (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

References:

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Stationary Reciprocating Internal Combustion Engines," EPA,-453/R-93-032, Research Triangle

AT-A-GLANCE TABLE FOR POINT SOURCES

Park, NC, July 1993

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.8.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Internal Combustion Engines - Gas - Large Sources

Control Measure Name: Air/Fuel Ratio Adjustment

Rule Name: Not Applicable

Pechan Measure Code: N0224L, N02204

POD: 22

Application: This control is the use of air/fuel ratio adjustment to reduce NOx emissions.

This control applies to large (>4,00 HP) gasoline powered internal combustion engines with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

20200202 Industrial, Natural Gas, Reciprocating

20300201 Natural Gas, Reciprocating

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 20% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by power (Pechan, 1998).

Engines less than 4,000 horsepower were considered large engines.

Capital and annual cost information was obtained from model engine data in the Alternative Control Techniques (ACT) document (EPA, 1993). A capital cost to annual cost ratio of 1.5 was developed to estimate default capital and operating and maintenance costs. From these determinations, default cost effectiveness values were assigned. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 15 years (EPA, 1993).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 25% (Pechan, 2001).

Cost Effectiveness: The default cost effectiveness value is \$380 per ton NOx reduced from both uncontrolled and RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

References:

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Stationary Reciprocating Internal Combustion Engines," EPA,-453/R-93-032, Research Triangle

AT-A-GLANCE TABLE FOR POINT SOURCES

Park, NC, July 1993

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.8.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Internal Combustion Engines - Gas - Large Sources

Control Measure Name: Air/Fuel + Ignition Retard

Rule Name: Not Applicable

Pechan Measure Code: N0227L, N02207

POD: 22

Application: This control is the use of air/fuel and ignition retard to reduce NOx emissions.

This control applies to large ($\geq 4,000$ HP) gasoline powered internal combustion engines with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

20200202 Industrial, Natural Gas, Reciprocating

20300201 Natural Gas, Reciprocating

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 30% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by power (Pechan, 1998).

Engines less than 4,000 horsepower were considered large engines.

Capital and annual cost information was obtained from model engine data in the Alternative Control Techniques (ACT) document (EPA, 1993). A capital cost to annual cost ratio of 1.2 was developed to estimate default capital and operating and maintenance costs. From these determinations, default cost effectiveness values were assigned. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 15 years (EPA, 1993).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 25% (Pechan, 2001).

Cost Effectiveness: The default cost effectiveness values are \$460 per ton NOx reduced from uncontrolled and \$150 per ton NOx reduced from RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

References:

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Stationary Reciprocating Internal Combustion Engines," EPA-453/R-93-032, Research Triangle

AT-A-GLANCE TABLE FOR POINT SOURCES

Park, NC, July 1993

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.8.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Internal Combustion Engines - Gas - Small Sources

Control Measure Name: Ignition Retard

Rule Name: Not Applicable

Pechan Measure Code: N0221S, N02201

POD: 22

Application: This control is the use of ignition retard technologies to reduce NOx emissions.

This applies to small (<4,000 HP) gasoline powered IC engines with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

20200202 Industrial, Natural Gas, Reciprocating

20200204 Natural Gas, Reciprocating: Cogeneration

20300201 Natural Gas, Reciprocating

20300204 Natural Gas, Cogeneration

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 20% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by power (Pechan, 1998).

Engines less than 4,000 horsepower were considered small engines.

Capital and annual cost information was obtained from model engine data in the Alternative Control Techniques (ACT) document (EPA, 1993). A capital cost to annual cost ratio of 1.2 was developed to estimate default capital and operating and maintenance costs. From these determinations, default cost effectiveness values were assigned. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 15 years (EPA, 1993).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 25% (Pechan, 2001).

Cost Effectiveness: The default cost effectiveness value is \$1,020 per ton NOx reduced from both uncontrolled RACT baselines (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

AT-A-GLANCE TABLE FOR POINT SOURCES

References:

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Stationary Reciprocating Internal Combustion Engines," EPA,-453/R-93-032, Research Triangle Park, NC, July 1993

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.8.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Internal Combustion Engines - Gas - Small Sources

Control Measure Name: Air/Fuel Ratio Adjustment

Rule Name: Not Applicable

Pechan Measure Code: N0224S

POD: 22

Application: This control is the use of air/fuel ratio adjustment to reduce NOx emissions.

This control applies to small (<4,00 HP) gasoline powered internal combustion engines with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

20200202 Industrial, Natural Gas, Reciprocating
20200204 Natural Gas, Reciprocating: Cogeneration
20300201 Natural Gas, Reciprocating
20300204 Natural Gas, Cogeneration

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 20% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by power (Pechan, 1998).

Engines less than 4,000 horsepower were considered small engines.

Capital and annual cost information was obtained from model engine data in the Alternative Control Techniques (ACT) document (EPA, 1993). A capital cost to annual cost ratio of 2.8 was developed to estimate default capital and operating and maintenance costs. From these determinations, default cost effectiveness values were assigned. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 15 years (EPA, 1993).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 25% (Pechan, 2001).

Cost Effectiveness: The default cost effectiveness value is \$1,570 per ton NOx reduced from both uncontrolled and RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

AT-A-GLANCE TABLE FOR POINT SOURCES

References:

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Stationary Reciprocating Internal Combustion Engines," EPA,-453/R-93-032, Research Triangle Park, NC, July 1993

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Internal Combustion Engines - Gas - Small Sources

Control Measure Name: Air/Fuel + Ignition Retard

Rule Name: Not Applicable

Pechan Measure Code: N0227S

POD: 22

Application: This control is the use of air/fuel and ignition retard to reduce NOx emissions.

This control applies to small (<4,000 HP) gasoline powered internal combustion engines with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√/*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 30% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by power (Pechan, 1998).

Engines less than 4,000 horsepower were considered small engines.

Capital and annual cost information was obtained from model engine data in the Alternative Control Techniques (ACT) document (EPA, 1993). A capital cost to annual cost ratio of 2.6 was developed to estimate default capital and operating and maintenance costs. From these determinations, default cost effectiveness values were assigned. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 15 years (EPA, 1993).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 25% (Pechan, 2001).

Cost Effectiveness: The default cost effectiveness values are \$1,440 per ton NOx reduced from uncontrolled and \$270 per ton NOx reduced from RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

References:

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Stationary Reciprocating Internal Combustion Engines," EPA-453/R-93-032, Research Triangle

AT-A-GLANCE TABLE FOR POINT SOURCES

Park, NC, July 1993

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.8.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Internal Combustion Engines - Oil - Small Sources

Control Measure Name: Ignition Retard

Rule Name: Not Applicable

Pechan Measure Code: N0211S, N02101

POD: 21

Application: This control is the use of ignition retard technologies to reduce NOx emissions.

This applies to small (<4,000 HP) oil IC engines with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

20200102 Distillate Oil (Diesel), Reciprocating

20200104 Industrial, Distillate Oil (Diesel), Reciprocating: Cogeneration

20200501 Residual/Crude Oil, Reciprocating

20300101 Commercial/Institutional, Distillate Oil (Diesel), Reciprocating

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 25% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by power (Pechan, 1998).

Engines less than 4,000 horsepower were considered small engines.

Capital and annual cost information was obtained from model engine data in the Alternative Control Techniques (ACT) document (EPA, 1993). A capital cost to annual cost ratio of 1.1 was developed to estimate default capital and operating and maintenance costs. From these determinations, default cost effectiveness values were assigned. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 15 years (EPA, 1993).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 25% (Pechan, 2001).

Cost Effectiveness: The default cost effectiveness value is \$770 per ton NOx reduced from both uncontrolled RACT baselines (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

AT-A-GLANCE TABLE FOR POINT SOURCES

References:

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Stationary Reciprocating Internal Combustion Engines," EPA,-453/R-93-032, Research Triangle Park, NC, July 1993

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.8.
.EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Stationary Reciprocating Internal Combustion Engines," EPA,-453/R-93-032, Research Triangle Park, NC, July 1993

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.8.
.EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Stationary Reciprocating Internal Combustion Engines," EPA,-453/R-93-032, Research Triangle Park, NC, July 1993

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.8.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Internal Combustion Engines - Oil - Small Sources

Control Measure Name: Selective Catalytic Reduction (SCR)

Rule Name: Not Applicable

Pechan Measure Code: N0214S, N02104

POD: 21

Application: This control is the selective catalytic reduction of NO_x through add-on controls. SCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NO_x) into molecular nitrogen (N₂) and water vapor (H₂O). The SCR utilizes a catalyst to increase the NO_x removal efficiency, which allows the process to occur at lower temperatures.

Applies to small (<1 ton NO_x per OSD) internal combustion engines with NO_x emissions greater than 10 tons per year.

Affected SCC:

20200102 Distillate Oil (Diesel), Reciprocating

20200104 Industrial, Distillate Oil (Diesel), Reciprocating: Cogeneration

20200501 Residual/Crude Oil, Reciprocating

20300101 Commercial/Institutional, Distillate Oil (Diesel), Reciprocating

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 80% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NO_x emission levels (Pechan, 1998).

Small source = emission levels less than 1 ton per ozone season day

Costs for stationary source NO_x control are based on an analysis of EPA's NO_x State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 15 years (EPA, 1993).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 25% (Pechan, 2001).

Cost Effectiveness: The cost effectiveness value (for both small and large sources) used in AirControlNET is \$2,340 per ton NO_x reduced from both uncontrolled and RACT baselines (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

Selective Catalytic Reduction (SCR) has been widely applied to stationary source, fossil fuel-fired, combustion units for emission control since the early 1970s. SCR is typically implemented on units requiring a higher level of NO_x control than achievable by SNCR or other combustion controls (EPA, 2002).

Like SNCR, SCR is based on the chemical reduction of the NO_x molecule. The primary difference between SNCR and SCR is that SCR uses a metal-based catalyst to increase the rate of reaction (EPA, 2002). A nitrogen based reducing reagent, such as ammonia or urea, is injected into the flue gas. The reagent reacts selectively with the flue gas NO_x within a specific temperature range and in the presence of the catalyst and oxygen to reduce the NO_x.

The use of a catalyst results in two advantages of the SCR process over SNCR, the higher NO_x reduction efficiency and the lower and broader temperature ranges. However, the decrease in reaction temperature and increase in efficiency is accompanied by a significant increase in capital and operating costs (EPA, 2002). The cost increase is due to the large amount of catalyst required.

The SCR system can utilize either aqueous or anhydrous ammonia as the reagent. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Today, catalyst formulations include single component, multi-component, or active phase with a support structure. Most catalyst formulations contain additional compounds or supports, providing thermal and structural stability or to increase surface area (EPA, 2002).

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include: reaction temperature range; residence time available in the optimum temperature range; degree of mixing between the injected reagent and the combustion gases; uncontrolled NO_x concentration level; molar ratio of injected reagent to uncontrolled NO_x; ammonia slip; catalyst activity; catalyst selectivity; pressure drop across the catalyst; catalyst pitch; catalyst deactivation; and catalyst management (EPA, 2001).

References:

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Stationary Reciprocating Internal Combustion Engines," EPA-453/R-93-032, Research Triangle Park, NC, July 1993.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Iron & Steel Mills - Annealing

Control Measure Name: Low NOx Burner

Rule Name: Not Applicable

Pechan Measure Code: N0361S, N03601

POD: 36

Application: This control is the use of low NOx burner (LNB) technology to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another.

This control is applicable to iron and steel annealing operations with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

30300934 Primary Metal Production, Steel (See 303015), Heat Treating Furnaces-Annealing

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 50% from uncontrolled

Equipment Life: 10 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The basis of the costs are model plant data contained in the Alternative Control Techniques (ACT) document for annealing, reheating and galvanizing (EPA, 1994). Capital, and annual cost information was obtained from control-specific cost data. Some O&M costs were included. Missing O&M costs were back calculated from annual costs (Pechan, 1998). From these determinations, an average cost per ton values was assigned along with a capital cost to annual cost ratio of 7.0. A discount rate of 7% was assumed for all sources. The equipment life is 10 years.

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than 55% (Pechan, 2001).

Cost Effectiveness: The default cost effectiveness value used in AirControlNET is \$570 per ton NOx reduced from both uncontrolled and RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNBs create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNBs create a lean combustion zone that is relatively cool due to the presence of

AT-A-GLANCE TABLE FOR POINT SOURCES

excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Iron and Steel Mills," EPA-453/R-94-065, Research Triangle Park, NC, September 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Iron & Steel Mills - Annealing

Control Measure Name: Low NOx Burner + Flue Gas Recirculation

Rule Name: Not Applicable

Pechan Measure Code: N0362S, N03602

POD: 36

Application: This control is the use of low NOx burner (LNB) technology and flue gas recirculation (FGR) to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another.

This control is applicable to iron and steel annealing operations with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

30300934 Primary Metal Production, Steel (See 303015), Heat Treating Furnaces-Annealing

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 60% from uncontrolled

Equipment Life: 10 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). The basis of the costs are model plant data in the Alternative Control Techniques (ACT) document (EPA, 1994). From this analysis, default cost per ton values are assigned along with a capital to annual costs ratio of 7.0. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 10 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 55% (Pechan, 2001).

Cost Effectiveness: The default cost effectiveness values are \$750 per ton NOx reduced from uncontrolled and \$250 per ton NOx reduced from RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNBs create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNBs create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

AT-A-GLANCE TABLE FOR POINT SOURCES

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Iron and Steel Mills," EPA-453/R-94-065, Research Triangle Park, NC, September 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Iron & Steel Mills - Annealing

Control Measure Name: Selective Non-Catalytic Reduction (SNCR)

Rule Name: Not Applicable

Pechan Measure Code: N0363S, N03603

POD: 36

Application: This control is the reduction of NO_x emission through selective non-catalytic reduction add-on controls. SNCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NO_x) into molecular nitrogen (N₂) and water vapor (H₂O).

This control applies to iron and steel mill annealing operations with uncontrolled NO_x emissions greater than 10 tons per year, classified under SCC 30300934.

Affected SCC:

30300934 Primary Metal Production, Steel (See 303015), Heat Treating Furnaces-Annealing

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 60% from uncontrolled

Equipment Life: 10 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NO_x emission levels (Pechan, 1998).

Small source = emission levels less than 1 ton per ozone season day

Large source = emission levels greater than 1 ton per ozone season day

Costs for stationary source NO_x control are based on an analysis of EPA's NO_x State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned for small sources. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 10 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than 55% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown is estimated by applying percentages of O&M breakdown for SCR as applied to process heaters, using detailed information found in Table 6-3 and Chapter 6 of the Process Heater ACT document. The breakdown was obtained using the average O&M costs for 3 annealing furnaces having capacities of 100, 200 and 300 MMBTU per hour.

Electricity: \$0.06 per kw-hr

Fuel (nat gas): \$2.00 per MMBTU

Ammonia: \$0.125 per lb

AT-A-GLANCE TABLE FOR POINT SOURCES

Cost Effectiveness: The cost effectiveness (for both small and large sources) used in AirControlNET for both reductions from baseline and reductions from RACT is \$1,640 per ton NO_x reduced (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

SNCR is the reduction of NO_x in flue gas to N₂ and water vapor. This reduction is done with a nitrogen based reducing reagent, such as ammonia or urea. The reagent can react with a number of flue gas components. However, the NO_x reduction reaction is favored for a specific temperature range and in the presence of oxygen (EPA, 2002).

Both ammonia and urea are used as reagents. The cost of the reagent represents a large part of the annual costs of an SNCR system. Ammonia is generally less expensive than urea. However, the choice of reagent is also based on physical properties and operational considerations (EPA, 2002).

Ammonia can be utilized in either aqueous or anhydrous form. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Urea based systems have several advantages, including several safety aspects. Urea is a nontoxic, less volatile liquid that can be stored and handled more safely than ammonia. Urea solution droplets can penetrate farther into the flue gas when injected into the boiler, enhancing mixing (EPA, 2002). Because of these advantages, urea is more commonly used than ammonia in large boiler applications.

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include:

Reaction temperature range;
Residence time available in the optimum temperature range;
Degree of mixing between the injected reagent and the combustion gases
Uncontrolled NO_x concentration level;
Molar ratio of injected reagent to uncontrolled NO_x ; and
Ammonia slip.

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Iron and Steel Mills," EPA-453/R-94-065, Research Triangle Park, NC, September 1994.

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Process Heaters," EPA-453/R-93-034, Research Triangle Park, NC, September 1993.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity

AT-A-GLANCE TABLE FOR POINT SOURCES

Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Iron & Steel Mills - Annealing

Control Measure Name: Low NOx Burner (LNB) + SCR

Rule Name: Not Applicable

Pechan Measure Code: N0364S, N03604

POD: 36

Application: This control is the use of low NOx burner (LNB) technology and selective catalytic reduction (SCR) to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another. SCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NOx) into molecular nitrogen (N2) and water vapor (H2O). The SCR utilizes a catalyst to increase the NOx removal efficiency, which allows the process to occur at lower temperatures.

This control is applicable to iron and steel annealing operations with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 80% from uncontrolled

Equipment Life: 10 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). The basis of the costs are model plant data in the Alternative Control Techniques (ACT) document (EPA, 1994). From this analysis, default cost per ton values are assigned along with a capital to annual costs ratio of 3.7. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 10 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than 55% (Pechan, 2001).

Cost Effectiveness: The default cost effectiveness values are \$1,720 per ton NOx reduced from uncontrolled and \$1,320 per ton NOx reduced from RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNB's create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNB's create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

Selective Catalytic Reduction (SCR) has been widely applied to stationary source, fossil fuel-fired, combustion units for emission control since the early 1970s. SCR is typically implemented on units requiring a higher level of NO_x control than achievable by SNCR or other combustion controls (EPA, 2002).

Like SNCR, SCR is based on the chemical reduction of the NO_x molecule. The primary difference between SNCR and SCR is that SCR uses a metal-based catalyst to increase the rate of reaction (EPA, 2002). A nitrogen based reducing reagent, such as ammonia or urea, is injected into the flue gas. The reagent reacts selectively with the flue gas NO_x within a specific temperature range and in the presence of the catalyst and oxygen to reduce the NO_x.

The use of a catalyst results in two advantages of the SCR process over SNCR, the higher NO_x reduction efficiency and the lower and broader temperature ranges. However, the decrease in reaction temperature and increase in efficiency is accompanied by a significant increase in capital and operating costs (EPA, 2002). The cost increase is due to the large amount of catalyst required.

The SCR system can utilize either aqueous or anhydrous ammonia as the reagent. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Today, catalyst formulations include single component, multi-component, or active phase with a support structure. Most catalyst formulations contain additional compounds or supports, providing thermal and structural stability or to increase surface area (EPA, 2002).

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include: reaction temperature range; residence time available in the optimum temperature range; degree of mixing between the injected reagent and the combustion gases; uncontrolled NO_x concentration level; molar ratio of injected reagent to uncontrolled NO_x; ammonia slip; catalyst activity; catalyst selectivity; pressure drop across the catalyst; catalyst pitch; catalyst deactivation; and catalyst management (EPA, 2001).

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Iron and Steel Mills," EPA-453/R-94-065, Research Triangle Park, NC, September 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air

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Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Iron & Steel Mills - Annealing - Small Sources

Control Measure Name: Selective Catalytic Reduction (SCR)

Rule Name: Not Applicable

Pechan Measure Code: N0365S, N03605

POD: 36

Application: This control is the selective catalytic reduction of NOx through add-on controls. SCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NOx) into molecular nitrogen (N₂) and water vapor (H₂O). The SCR utilizes a catalyst to increase the NOx removal efficiency, which allows the process to occur at lower temperatures.

Applies to small (<1 ton NOx per OSD) iron and steel annealing operations with NOx emissions greater than 10 tons per year.

Affected SCC:

30300934 Primary Metal Production, Steel (See 303015), Heat Treating Furnaces-Annealing

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 85% from uncontrolled

Equipment Life: 10 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NOx emission levels (Pechan, 1998).

Small source = emission levels less than 1 ton per ozone season day

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 10 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than 55% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown is estimated by applying percentages of O&M breakdown for SCR as applied to process heaters, using detailed information found in Table 6-4 and Chapter 6 of the Process Heater ACT document. The breakdown was obtained using the average O&M costs for 3 annealing furnaces having capacities of 100, 200 and 300 MMBTU per hour.

Electricity: \$0.06 per kw-hr

Fuel (nat gas): \$2.00 per MMBTU

Ammonia: \$0.125 per lb

AT-A-GLANCE TABLE FOR POINT SOURCES

Cost Effectiveness: The cost effectiveness value (for both small and large sources) used in AirControlNET is \$3,830 per ton NO_x reduced from both uncontrolled and RACT baselines (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

Selective Catalytic Reduction (SCR) has been widely applied to stationary source, fossil fuel-fired, combustion units for emission control since the early 1970s. SCR is typically implemented on units requiring a higher level of NO_x control than achievable by SNCR or other combustion controls (EPA, 2002).

Like SNCR, SCR is based on the chemical reduction of the NO_x molecule. The primary difference between SNCR and SCR is that SCR uses a metal-based catalyst to increase the rate of reaction (EPA, 2002). A nitrogen based reducing reagent, such as ammonia or urea, is injected into the flue gas. The reagent reacts selectively with the flue gas NO_x within a specific temperature range and in the presence of the catalyst and oxygen to reduce the NO_x.

The use of a catalyst results in two advantages of the SCR process over SNCR, the higher NO_x reduction efficiency and the lower and broader temperature ranges. However, the decrease in reaction temperature and increase in efficiency is accompanied by a significant increase in capital and operating costs (EPA, 2002). The cost increase is due to the large amount of catalyst required.

The SCR system can utilize either aqueous or anhydrous ammonia as the reagent. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Today, catalyst formulations include single component, multi-component, or active phase with a support structure. Most catalyst formulations contain additional compounds or supports, providing thermal and structural stability or to increase surface area (EPA, 2002).

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include: reaction temperature range; residence time available in the optimum temperature range; degree of mixing between the injected reagent and the combustion gases; uncontrolled NO_x concentration level; molar ratio of injected reagent to uncontrolled NO_x; ammonia slip; catalyst activity; catalyst selectivity; pressure drop across the catalyst; catalyst pitch; catalyst deactivation; and catalyst management (EPA, 2001).

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Iron and Steel Mills," EPA-453/R-94-065, Research Triangle Park, NC, September 1994.

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Process Heaters," EPA-453/R-93-034, Research Triangle Park, NC, September 1993.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC,

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January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Iron & Steel Mills - Annealing - Small Sources

Control Measure Name: Low NOx Burner (LNB) + Selective Catalytic Reduction (SCR)

Rule Name: Not Applicable

Pechan Measure Code: N0366S, N03606

POD: 36

Application: This control is the use of low NOx burner (LNB) technology and selective catalytic reduction (SCR) to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another. SCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NOx) into molecular nitrogen (N₂) and water vapor (H₂O). The SCR utilizes a catalyst to increase the NOx removal efficiency, which allows the process to occur at lower temperatures.

This control is applicable to small (<1 ton NOx per OSD) iron and steel annealing operations with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

30300934 Primary Metal Production, Steel (See 303015), Heat Treating Furnaces-Annealing

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 90% from uncontrolled

Equipment Life: 10 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NOx emissions (Pechan, 1998).

Small source = less than 1 ton NOx emissions per ozone season day

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). The basis of the costs are model plant data in the Alternative Control Techniques (ACT) document (EPA, 1994). From this analysis, default cost per ton values are assigned along with a capital to annual costs ratio of 5.1. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 10 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than 55% (Pechan, 2001).

Cost Effectiveness: The default cost effectiveness values are \$4,080 per ton NOx reduced from uncontrolled and \$3,720 per ton NOx reduced from RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNB's create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNB's create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

Selective Catalytic Reduction (SCR) has been widely applied to stationary source, fossil fuel-fired, combustion units for emission control since the early 1970s. SCR is typically implemented on units requiring a higher level of NO_x control than achievable by SNCR or other combustion controls (EPA, 2002).

Like SNCR, SCR is based on the chemical reduction of the NO_x molecule. The primary difference between SNCR and SCR is that SCR uses a metal-based catalyst to increase the rate of reaction (EPA, 2002). A nitrogen based reducing reagent, such as ammonia or urea, is injected into the flue gas. The reagent reacts selectively with the flue gas NO_x within a specific temperature range and in the presence of the catalyst and oxygen to reduce the NO_x.

The use of a catalyst results in two advantages of the SCR process over SNCR, the higher NO_x reduction efficiency and the lower and broader temperature ranges. However, the decrease in reaction temperature and increase in efficiency is accompanied by a significant increase in capital and operating costs (EPA, 2002). The cost increase is due to the large amount of catalyst required.

The SCR system can utilize either aqueous or anhydrous ammonia as the reagent. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Today, catalyst formulations include single component, multi-component, or active phase with a support structure. Most catalyst formulations contain additional compounds or supports, providing thermal and structural stability or to increase surface area (EPA, 2002).

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include: reaction temperature range; residence time available in the optimum temperature range; degree of mixing between the injected reagent and the combustion gases; uncontrolled NO_x concentration level; molar ratio of injected reagent to uncontrolled NO_x; ammonia slip; catalyst activity; catalyst selectivity; pressure drop across the catalyst; catalyst pitch; catalyst deactivation; and catalyst management (EPA, 2001).

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Iron and Steel Mills," EPA-453/R-94-065, Research Triangle Park, NC, September 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air

AT-A-GLANCE TABLE FOR POINT SOURCES

Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Iron & Steel Mills - Galvanizing

Control Measure Name: Low NOx Burner

Rule Name: Not Applicable

Pechan Measure Code: N0371S, N03701

POD: 37

Application: This control is the use of low NOx burner (LNB) technology to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another.

This control is applicable to iron and steel galvanizing operations (SCC 30300936) with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

30300936 Primary Metal Production, Steel Manufacturing (See 3-03-015), Coating: Tin, Zinc, etc.

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 50% from uncontrolled

Equipment Life: 9 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The basis of the costs are model plant data contained in the Alternative Control Techniques (ACT) document for annealing, reheating and galvanizing (EPA, 1994). Capital, and annual cost information was obtained from control-specific cost data. Some O&M costs were included. Missing O&M costs were back calculated from annual costs (Pechan, 1998). From these determinations, an average cost per ton values was assigned along with a capital cost to annual cost ratio of 6.5. A discount rate of 7% was assumed for all sources. The equipment life is 9 years.

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than 55% (Pechan, 2001).

Cost Effectiveness: The default cost effectiveness value used in AirControlNET is \$490 per ton NOx reduced from both uncontrolled and RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNBs create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNBs create a lean combustion zone that is relatively cool due to the presence of

AT-A-GLANCE TABLE FOR POINT SOURCES

excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Iron and Steel Mills," EPA-453/R-94-065, Research Triangle Park, NC, September 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Iron & Steel Mills - Galvanizing

Control Measure Name: Low NOx Burner + Flue Gas Recirculation

Rule Name: Not Applicable

Pechan Measure Code: N0372S, N03702

POD: 37

Application: This control is the use of low NOx burner (LNB) technology and flue gas recirculation (FGR) to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another.

This control is applicable to iron and steel galvanizing operations with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

30300936 Primary Metal Production, Steel Manufacturing (See 3-03-015), Coating: Tin, Zinc, etc.

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 60% from uncontrolled

Equipment Life: 9 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). The basis of the costs are model plant data in the Alternative Control Techniques (ACT) document (EPA, 1994). From this analysis, default cost per ton values are assigned along with a capital to annual costs ratio of 6.5. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 9 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 55% (Pechan, 2001).

Cost Effectiveness: The default cost effectiveness values are \$580 per ton NOx reduced from uncontrolled and \$190 per ton NOx reduced from RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNBs create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNBs create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

AT-A-GLANCE TABLE FOR POINT SOURCES

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Iron and Steel Mills," EPA-453/R-94-065, Research Triangle Park, NC, September 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Iron & Steel Mills - Reheating

Control Measure Name: Low Excess Air (LEA)

Rule Name: Not Applicable

Pechan Measure Code: N0351S, N03501

POD: 35

Application: The reduction in NO_x emissions is achieved through the use of low excess air techniques, such that there is less available oxygen convert fuel nitrogen to NO_x.

This control applies to iron & steel reheating furnaces classified under SCC 30300933.

Affected SCC:

30300933 Primary Metal Production, Steel Manufacturing (See 3-03-015), Reheat Furnaces

Pollutant(s)	PM10	PM2.5	EC	OC	NO _x	VOC	SO ₂	NH ₃	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 13% from uncontrolled

Equipment Life: 10 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Capital and annual cost information was obtained from model engine data in the Alternative Control Techniques (ACT) document (EPA, 1994). A capital cost to annual cost ratio of 3.8 was developed to estimate default capital and operating and maintenance costs. From these determinations, default cost effectiveness values were assigned. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 10 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies greater than 15% and less than or equal to 25% (Pechan, 2001).

Cost Effectiveness: The default cost effectiveness value is \$1,320 per ton NO_x reduced from both uncontrolled RACT baselines (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

Low excess air works by reducing levels of excess air to the combustor, usually by adjustments to air registers and/or fuel injection positions, or through control of overfire air dampers. The lower oxygen concentration in the burner zone reduces conversion of the fuel nitrogen to NO_x. Also, under excess air conditions in the flame zone, a greater portion of fuel-bound nitrogen is converted to N₂ therefore reducing the formation of fuel NO_x (ERG, 2000).

AT-A-GLANCE TABLE FOR POINT SOURCES

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Iron and Steel Mills," EPA-453/R-94-065, Research Triangle Park, NC, September 1994.

ERG, 2000: Eastern Research Group, Inc., "How to Incorporate the Effects of Air Pollution Control Device Efficiencies and Malfunctions into Emission Inventory Estimates," prepared for Emission Inventory Improvement Program, Point Sources Committee, July 2000.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.8.

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Stationary Reciprocating Internal Combustion Engines," EPA-453/R-93-032, Research Triangle Park, NC, July 1993

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.8.

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Stationary Reciprocating Internal Combustion Engines," EPA-453/R-93-032, Research Triangle Park, NC, July 1993

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.8.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Iron & Steel Mills - Reheating

Control Measure Name: Low NOx Burner

Rule Name: Not Applicable

Pechan Measure Code: N0352S, N03502

POD: 35

Application: This control is the use of low NOx burner (LNB) technology to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another.

This control is applicable to iron and steel reheating operations (SCC 30300933) with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

30300933 Primary Metal Production, Steel Manufacturing (See 3-03-015), Reheat Furnaces

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 66% from uncontrolled

Equipment Life: 5 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The basis of the costs are model plant data contained in the Alternative Control Techniques (ACT) document for annealing, reheating and galvanizing (EPA, 1994). Capital, and annual cost information was obtained from control-specific cost data. Some O&M costs were included. Missing O&M costs were back calculated from annual costs (Pechan, 1998). From these determinations, an average cost per ton values was assigned along with a capital cost to annual cost ratio of 4.1. A discount rate of 7% was assumed for all sources. The equipment life is 5 years.

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies greater than 15% and less than or equal to 25% (Pechan, 2001).

Cost Effectiveness: The default cost effectiveness value used in AirControlNET is \$300 per ton NOx reduced from both uncontrolled and RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNBs create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion

AT-A-GLANCE TABLE FOR POINT SOURCES

zone. Staged-fuel LNBs create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Iron and Steel Mills," EPA-453/R-94-065, Research Triangle Park, NC, September 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Iron & Steel Mills - Reheating

Control Measure Name: Low NOx Burner + Flue Gas Recirculation

Rule Name: Not Applicable

Pechan Measure Code: N0353S, N03503

POD: 35

Application: This control is the use of low NOx burner (LNB) technology and flue gas recirculation (FGR) to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another.

This control is applicable to reheating processes in iron and steel mills with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

30300933 Primary Metal Production, Steel Manufacturing (See 3-03-015), Reheat Furnaces

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 77% from uncontrolled

Equipment Life: 5 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). The basis of the costs are model plant data in the Alternative Control Techniques (ACT) document (EPA, 1994). From this analysis, default cost per ton values are assigned along with a capital to annual costs ratio of 4.1. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 5 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies greater than 15% and less than or equal to 25% (Pechan, 2001).

Cost Effectiveness: The default cost effectiveness values are \$380 per ton NOx reduced from uncontrolled and \$150 per ton NOx reduced from RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNBs create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNBs create a lean combustion zone that is relatively cool due to the presence of

AT-A-GLANCE TABLE FOR POINT SOURCES

excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Iron and Steel Mills," EPA-453/R-94-065, Research Triangle Park, NC, September 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Iron Production; Blast Furnaces; Blast Heating Stoves

Control Measure Name: Low NOx Burner + Flue Gas Recirculation

Rule Name: Not Applicable

Pechan Measure Code: N0673S, N06703

POD: 67

Application: This control is the use of low NOx burner (LNB) technology and flue gas recirculation (FGR) to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another.

This control is applicable to reheating processes in iron production operations with blast heating stoves and uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

30300824 Iron Production (See 3-03-015), Blast Heating Stoves

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 77% from uncontrolled

Equipment Life: 5 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). The basis of the costs are model plant data in the Alternative Control Techniques (ACT) document (EPA, 1994). From this analysis, default cost per ton values are assigned along with a capital to annual costs ratio of 4.1. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 5 years (EPA, 1994).

Cost Effectiveness: The default cost effectiveness values are \$380 per ton NOx reduced from uncontrolled and \$150 per ton NOx reduced from RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNBs create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNBs create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

AT-A-GLANCE TABLE FOR POINT SOURCES

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Iron and Steel Mills," EPA-453/R-94-065, Research Triangle Park, NC, September 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Lime Kilns

Control Measure Name: Mid-Kiln Firing

Rule Name: Not Applicable

Pechan Measure Code: N0581, N0581L, N0581S, N05801 **POD:** 58

Application: This control is the use of mid- kiln firing to reduce NOx emissions.

This control applies to lime kilns with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

30501603 Mineral Products, Lime Manufacture, Calcining: Vertical Kiln

30501604 Mineral Products, Lime, Calcining-Rotary Kiln (See SCCs 305016-18,-19,-20,-21)

30501605 Mineral Products, Lime Manufacture, Calcining: Gas-fired Calcimatic Kiln

30501606 Lime Manufacture, Fluidized Bed Kiln

30700106 Pulp and Paper and Wood Products, Sulfate (Kraft) Pulping, Lime Kiln

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 30% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Cost equations for cement plants NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). The basis of the costs are model plant data contained in the Alternative Control Techniques (ACT) document for wet and dry kilns (EPA, 1994). Capital, and annual cost information is obtained from control-specific cost data. O&M costs were back calculated from annual costs. From these determinations, an average cost per ton values was assigned along with a capital cost to annual cost ratio of 3.4. A discount rate of 10% and an equipment life of 15 years was assumed.

O&M Cost Components: These were estimated for lime kilns using the example applications of this control technique to the cement manufacturing. See the cement kiln documentation for more information.

Cost Effectiveness: The default cost effectiveness value is \$460 per ton NOx reduced from both uncontrolled and RACT baselines (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

AT-A-GLANCE TABLE FOR POINT SOURCES

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Cement Manufacturing," EPA,-453/R-94-004, Research Triangle Park, NC, March 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Lime Kilns

Control Measure Name: Low NOx Burner

Rule Name: Not Applicable

Pechan Measure Code: N0582S, N05802

POD: 58

Application: This control is the use of low NOx burner (LNB) technology to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another.

This control is applicable to lime kilns with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

30501603 Mineral Products, Lime Manufacture, Calcining: Vertical Kiln
30501604 Mineral Products, Lime, Calcining-Rotary Kiln (See SCCs 305016-18,-19,-20,-21)
30501605 Mineral Products, Lime Manufacture, Calcining: Gas-fired Calcimatic Kiln
30501606 Lime Manufacture, Fluidized Bed Kiln
30700106 Pulp and Paper and Wood Products, Sulfate (Kraft) Pulping, Lime Kiln

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 30% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The basis of the costs are model plant data contained in the Alternative Control Techniques (ACT) document (EPA, 1994). Capital, and annual cost information was obtained from control-specific cost data. O&M costs were back calculated from annual costs (Pechan, 1998). From these determinations, an average cost per ton values was assigned along with a capital cost to annual cost ratio of 5.0. A discount rate of 7% was assumed for all sources. The equipment life is 15 years.

O&M Cost Components: These were estimated for lime kilns using the example applications of this control technique to the cement manufacturing. See the cement kiln documentation for more information.

Cost Effectiveness: The default cost effectiveness value used in AirControlNET is \$560 per ton NOx reduced from both uncontrolled and RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 1998

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNBs create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNBs create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Cement Manufacturing," EPA-453/R-94-004, Research Triangle Park, NC, March 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Lime Kilns

Control Measure Name: Selective Non-Catalytic Reduction (SNCR) Urea Based

Rule Name: Not Applicable

Pechan Measure Code: N0583S, N05803

POD: 58

Application: This control is the reduction of NO_x emission through selective non-catalytic reduction add-on controls. SNCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NO_x) into molecular nitrogen (N₂) and water vapor (H₂O).

This control applies to lime kilns with uncontrolled NO_x emissions greater than 10 tons per year.

Affected SCC:

30501603 Mineral Products, Lime Manufacture, Calcining: Vertical Kiln
30501604 Mineral Products, Lime, Calcining-Rotary Kiln (See SCCs 305016-18,-19,-20,-21)
30501605 Mineral Products, Lime Manufacture, Calcining: Gas-fired Calcimatic Kiln
30501606 Lime Manufacture, Fluidized Bed Kiln
30700106 Pulp and Paper and Wood Products, Sulfate (Kraft) Pulping, Lime Kiln

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 50% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NO_x emission levels (Pechan, 1998).

Small source = emission levels less than 1 ton per ozone season day

Large source = emission levels greater than 1 ton per ozone season day

Costs for stationary source NO_x control are based on an analysis of EPA's NO_x State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned for small sources. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 15 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than 70% (Pechan, 2001).

O&M Cost Components: These were estimated for lime kilns using the example applications of this control technique to the cement manufacturing. See the cement kiln documentation for more information.

Cost Effectiveness: The cost effectiveness (for both small and large sources) used in AirControlNET for both reductions from baseline and reductions from RACT is

AT-A-GLANCE TABLE FOR POINT SOURCES

\$770 per ton NOx reduced (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

SNCR is the reduction of NOx in flue gas to N₂ and water vapor. This reduction is done with a nitrogen based reducing reagent, such as ammonia or urea. The reagent can react with a number of flue gas components. However, the NOx reduction reaction is favored for a specific temperature range and in the presence of oxygen (EPA, 2002).

Both ammonia and urea are used as reagents. The cost of the reagent represents a large part of the annual costs of an SNCR system. Ammonia is generally less expensive than urea. However, the choice of reagent is also based on physical properties and operational considerations (EPA, 2002).

Ammonia can be utilized in either aqueous or anhydrous form. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Urea based systems have several advantages, including several safety aspects. Urea is a nontoxic, less volatile liquid that can be stored and handled more safely than ammonia. Urea solution droplets can penetrate farther into the flue gas when injected into the boiler, enhancing mixing (EPA, 2002). Because of these advantages, urea is more commonly used than ammonia in large boiler applications.

The rate of reaction determines the amount of NOx removed from the flue gas. The important design and operational factors that affect the rate of reduction include:

Reaction temperature range;
Residence time available in the optimum temperature range;
Degree of mixing between the injected reagent and the combustion gases
Uncontrolled NOx concentration level;
Molar ratio of injected reagent to uncontrolled NOx ; and
Ammonia slip.

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Cement Manufacturing," EPA-453/R-94-004, Research Triangle Park, NC, March, 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection

AT-A-GLANCE TABLE FOR POINT SOURCES

Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Lime Kilns

Control Measure Name: Selective Non-Catalytic Reduction (SNCR) Ammonia Based

Rule Name: Not Applicable

Pechan Measure Code: N0584S, N05804

POD: 58

Application: This control is the reduction of NO_x emission through ammonia based selective non-catalytic reduction add-on controls. SNCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NO_x) into molecular nitrogen (N₂) and water vapor (H₂O).

This control applies to lime kilns with uncontrolled NO_x emissions greater than 10 tons per year.

Affected SCC:

30501603 Mineral Products, Lime Manufacture, Calcining: Vertical Kiln

30501604 Mineral Products, Lime, Calcining-Rotary Kiln (See SCCs 305016-18,-19,-20,-21)

30501605 Mineral Products, Lime Manufacture, Calcining: Gas-fired Calcimatic Kiln

30501606 Lime Manufacture, Fluidized Bed Kiln

30700106 Pulp and Paper and Wood Products, Sulfate (Kraft) Pulping, Lime Kiln

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 50% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NO_x emission levels (Pechan, 1998).

Small source = emission levels less than 1 ton per ozone season day

Large source = emission levels greater than 1 ton per ozone season day

Costs for stationary source NO_x control are based on an analysis of EPA's NO_x State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned for small sources. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 15 years (EPA, 1994).

O&M Cost Components: These were estimated for lime kilns using the example applications of this control technique to the cement manufacturing. See the cement kiln documentation for more information.

Cost Effectiveness: The cost effectiveness (for both small and large sources) used in AirControlNET for both reductions from baseline and reductions from RACT is \$850 per ton NO_x reduced (1990\$).

Comments:

AT-A-GLANCE TABLE FOR POINT SOURCES

Status: Demonstrated	Last Reviewed: 1998
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Additional Information:

SNCR is the reduction of NO_x in flue gas to N₂ and water vapor. This reduction is done with a nitrogen based reducing reagent, such as ammonia or urea. The reagent can react with a number of flue gas components. However, the NO_x reduction reaction is favored for a specific temperature range and in the presence of oxygen (EPA, 2002).

Ammonia can be utilized in either aqueous or anhydrous form. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include:

Reaction temperature range;
Residence time available in the optimum temperature range;
Degree of mixing between the injected reagent and the combustion gases
Uncontrolled NO_x concentration level;
Molar ratio of injected reagent to uncontrolled NO_x ; and
Ammonia slip.

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Cement Manufacturing," EPA,-453/R-94-004, Research Triangle Park, NC, March 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Lime Kilns

Control Measure Name: Selective Catalytic Reduction (SCR)

Rule Name: Not Applicable

Pechan Measure Code: N0585S, N05805

POD: 58

Application: This control is the selective catalytic reduction of NO_x through add-on controls. SCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NO_x) into molecular nitrogen (N₂) and water vapor (H₂O). The SCR utilizes a catalyst to increase the NO_x removal efficiency, which allows the process to occur at lower temperatures.

This applies to lime kilns with NO_x emissions greater than 10 tons per year.

Affected SCC:

30501603 Mineral Products, Lime Manufacture, Calcining: Vertical Kiln
30501604 Mineral Products, Lime, Calcining-Rotary Kiln (See SCCs 305016-18,-19,-20,-21)
30501605 Mineral Products, Lime Manufacture, Calcining: Gas-fired Calcimatic Kiln
30501606 Lime Manufacture, Fluidized Bed Kiln
30700106 Pulp and Paper and Wood Products, Sulfate (Kraft) Pulping, Lime Kiln

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 80% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NO_x emission levels (Pechan, 1998).

Small source = emission levels less than 1 ton per ozone season day

Large source = emission levels greater than 1 ton per ozone season day

Costs for stationary source NO_x control are based on an analysis of EPA's NO_x State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 15 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than 70% (Pechan, 2001).

O&M Cost Components: These were estimated for lime kilns using the example applications of this control technique to the cement manufacturing. See the cement kiln documentation for more information.

Cost Effectiveness: The cost effectiveness value (for both small and large sources) used in AirControlNET is \$3,370 per ton NO_x reduced from both uncontrolled and RACT baselines (1990\$).

AT-A-GLANCE TABLE FOR POINT SOURCES

Comments:**Status:** Demonstrated**Last Reviewed:** 2001

Additional Information:

Selective Catalytic Reduction (SCR) has been widely applied to stationary source, fossil fuel-fired, combustion units for emission control since the early 1970s. SCR is typically implemented on units requiring a higher level of NO_x control than achievable by SNCR or other combustion controls (EPA, 2002).

Like SNCR, SCR is based on the chemical reduction of the NO_x molecule. The primary difference between SNCR and SCR is that SCR uses a metal-based catalyst to increase the rate of reaction (EPA, 2002). A nitrogen based reducing reagent, such as ammonia or urea, is injected into the flue gas. The reagent reacts selectively with the flue gas NO_x within a specific temperature range and in the presence of the catalyst and oxygen to reduce the NO_x.

The use of a catalyst results in two advantages of the SCR process over SNCR, the higher NO_x reduction efficiency and the lower and broader temperature ranges. However, the decrease in reaction temperature and increase in efficiency is accompanied by a significant increase in capital and operating costs (EPA, 2002). The cost increase is due to the large amount of catalyst required.

The SCR system can utilize either aqueous or anhydrous ammonia as the reagent. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Today, catalyst formulations include single component, multi-component, or active phase with a support structure. Most catalyst formulations contain additional compounds or supports, providing thermal and structural stability or to increase surface area (EPA, 2002).

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include: reaction temperature range; residence time available in the optimum temperature range; degree of mixing between the injected reagent and the combustion gases; uncontrolled NO_x concentration level; molar ratio of injected reagent to uncontrolled NO_x; ammonia slip; catalyst activity; catalyst selectivity; pressure drop across the catalyst; catalyst pitch; catalyst deactivation; and catalyst management (EPA, 2001).

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Iron and Steel Mills," EPA-453/R-94-065, Research Triangle Park, NC, September 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter

AT-A-GLANCE TABLE FOR POINT SOURCES

Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Medical Waste Incinerators

Control Measure Name: Selective Non-Catalytic Reduction (SNCR)

Rule Name: Not Applicable

Pechan Measure Code: N0391S, N03901

POD: 39

Application: This control is the reduction of NO_x emission through selective non-catalytic reduction add-on controls. SNCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NO_x) into molecular nitrogen (N₂) and water vapor (H₂O).

This control applies to medical waste incinerators (SCC 50200505) with uncontrolled NO_x emissions greater than 10 tons per year.

Affected SCC:

50200505 Solid Waste Disposal-Commercial/Institutional, Incineration-Special, Medical Infectious

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 45% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NO_x emission levels (Pechan, 1998).

Small source = emission levels less than 1 ton per ozone season day

Large source = emission levels greater than 1 ton per ozone season day

Costs for stationary source NO_x control are based on an analysis of EPA's NO_x State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned for small sources. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 20 years (STAPPA/ALAPCO, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than 70% (Pechan, 2001).

Cost Effectiveness: The cost effectiveness (for both small and large sources) used in AirControlNET for both reductions from baseline and reductions from RACT is \$4,510 per ton NO_x reduced (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

SNCR is the reduction of NO_x in flue gas to N₂ and water vapor. This reduction is done with a nitrogen based reducing reagent, such as ammonia or urea. The reagent can react with a number of flue gas components. However, the NO_x reduction reaction is favored for a specific temperature range and in the presence of oxygen (EPA, 2002).

Both ammonia and urea are used as reagents. The cost of the reagent represents a large part of the annual costs of an SNCR system. Ammonia is generally less expensive than urea. However, the choice of reagent is also based on physical properties and operational considerations (EPA, 2002).

Ammonia can be utilized in either aqueous or anhydrous form. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Urea based systems have several advantages, including several safety aspects. Urea is a nontoxic, less volatile liquid that can be stored and handled more safely than ammonia. Urea solution droplets can penetrate farther into the flue gas when injected into the boiler, enhancing mixing (EPA, 2002). Because of these advantages, urea is more commonly used than ammonia in large boiler applications.

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include:

Reaction temperature range;
Residence time available in the optimum temperature range;
Degree of mixing between the injected reagent and the combustion gases
Uncontrolled NO_x concentration level;
Molar ratio of injected reagent to uncontrolled NO_x ; and
Ammonia slip.

References:

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

STAPPA/ALAPCO, 1994: State and Territorial Air Pollution Program Administrators/Association of Local Air Pollution Officials, "Controlling Nitrogen Oxides Under the Clean Air Act: A Menu of Options," Washington, DC, July 1994.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Municipal Waste Combustors

Control Measure Name: Selective Non-Catalytic Reduction (SNCR)

Rule Name: Not Applicable

Pechan Measure Code: N0381S, N03801

POD: 38

Application: This control is the reduction of NO_x emission through selective non-catalytic reduction add-on controls. SNCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NO_x) into molecular nitrogen (N₂) and water vapor (H₂O).

This control applies to municipal waste combustors with uncontrolled NO_x emissions greater than 10 tons per year.

Affected SCC:

50100101 Solid Waste Disposal-Government, Municipal Incineration, Starved Air-Multiple Chamber
50100102 Municipal Incineration, Mass Burn: Single Chamber
50100103 Municipal Incineration, Refuse Derived Fuel

Pollutant(s)	PM10	PM2.5	EC	OC	NO _x	VOC	SO ₂	NH ₃	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 45% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NO_x emission levels (Pechan, 1998).

Small source = emission levels less than 1 ton per ozone season day

Large source = emission levels greater than 1 ton per ozone season day

Costs for stationary source NO_x control are based on an analysis of EPA's NO_x State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned for small sources. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 20 years (EPA, 1994).

O&M Cost Components: The O&M cost breakdown is estimated using the information in Chapter and Appendix A of the MWC ACT document. The cost outputs for conventional SNCR applied to the 400 ton per day model combustor (Table 3-3) are used to estimate the O&M cost breakdown. The tipping fee (\$1.47 per ton) is included as a waste disposal cost (direct annual cost).

Electricity Cost: 0.046 \$/kW-hr

Cost Effectiveness: The cost effectiveness (for both small and large sources) used in AirControlNET for both reductions from baseline and reductions from RACT is \$1,130 per ton NO_x reduced (1990\$).

AT-A-GLANCE TABLE FOR POINT SOURCES

Comments:**Status:** Demonstrated**Last Reviewed:** 1998

Additional Information:

SNCR is the reduction of NO_x in flue gas to N₂ and water vapor. This reduction is done with a nitrogen based reducing reagent, such as ammonia or urea. The reagent can react with a number of flue gas components. However, the NO_x reduction reaction is favored for a specific temperature range and in the presence of oxygen (EPA, 2002).

Both ammonia and urea are used as reagents. The cost of the reagent represents a large part of the annual costs of an SNCR system. Ammonia is generally less expensive than urea. However, the choice of reagent is also based on physical properties and operational considerations (EPA, 2002).

Ammonia can be utilized in either aqueous or anhydrous form. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Urea based systems have several advantages, including several safety aspects. Urea is a nontoxic, less volatile liquid that can be stored and handled more safely than ammonia. Urea solution droplets can penetrate farther into the flue gas when injected into the boiler, enhancing mixing (EPA, 2002). Because of these advantages, urea is more commonly used than ammonia in large boiler applications.

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include:

Reaction temperature range;
Residence time available in the optimum temperature range;
Degree of mixing between the injected reagent and the combustion gases
Uncontrolled NO_x concentration level;
Molar ratio of injected reagent to uncontrolled NO_x ; and
Ammonia slip.

References:

EPA, 1994: U.S. Environmental Protection Agency, Radian Corporation, "Alternative Control Techniques Document-- NO_x Emissions from Municipal Waste Combustion," EPA-600/R-94-208, Research Triangle Park, NC, December 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Natural Gas Production; Compressors - Small Sources

Control Measure Name: Selective Catalytic Reduction (SCR)

Rule Name: Not Applicable

Pechan Measure Code: N08012

POD: 80

Application: This control is the selective catalytic reduction of NO_x through add-on controls. SCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NO_x) into molecular nitrogen (N₂) and water vapor (H₂O). The SCR utilizes a catalyst to increase the NO_x removal efficiency, which allows the process to occur at lower temperatures.

Applies to small (<1 ton NO_x per OSD) compressors used in natural gas production operations with NO_x emissions greater than 10 tons per year.

Affected SCC:

31000203 Natural Gas Production, Compressors

Pollutant(s)	PM10	PM2.5	EC	OC	NO _x	VOC	SO ₂	NH ₃	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 20% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NO_x emission levels (Pechan, 1998).

Small source = emission levels less than 1 ton per ozone season day

Costs for stationary source NO_x control are based on an analysis of EPA's NO_x State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 15 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than 70% (Pechan, 2001).

Cost Effectiveness: The cost effectiveness value used in AirControlNET is \$1,651 per ton NO_x reduced from both uncontrolled and RACT baselines (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

Selective Catalytic Reduction (SCR) has been widely applied to stationary source, fossil fuel-fired, combustion units for emission control since the early 1970s. SCR is typically implemented on units requiring a higher level of NO_x control than achievable by SNCR or other combustion controls (EPA,

AT-A-GLANCE TABLE FOR POINT SOURCES

2002).

Like SNCR, SCR is based on the chemical reduction of the NO_x molecule. The primary difference between SNCR and SCR is that SCR uses a metal-based catalyst to increase the rate of reaction (EPA, 2002). A nitrogen based reducing reagent, such as ammonia or urea, is injected into the flue gas. The reagent reacts selectively with the flue gas NO_x within a specific temperature range and in the presence of the catalyst and oxygen to reduce the NO_x.

The use of a catalyst results in two advantages of the SCR process over SNCR, the higher NO_x reduction efficiency and the lower and broader temperature ranges. However, the decrease in reaction temperature and increase in efficiency is accompanied by a significant increase in capital and operating costs (EPA, 2002). The cost increase is due to the large amount of catalyst required.

The SCR system can utilize either aqueous or anhydrous ammonia as the reagent. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Today, catalyst formulations include single component, multi-component, or active phase with a support structure. Most catalyst formulations contain additional compounds or supports, providing thermal and structural stability or to increase surface area (EPA, 2002).

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include: reaction temperature range; residence time available in the optimum temperature range; degree of mixing between the injected reagent and the combustion gases; uncontrolled NO_x concentration level; molar ratio of injected reagent to uncontrolled NO_x; ammonia slip; catalyst activity; catalyst selectivity; pressure drop across the catalyst; catalyst pitch; catalyst deactivation; and catalyst management (EPA, 2001).

References:

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Stationary Reciprocating Internal Combustion Engines," EPA-453/R-93-032, Research Triangle Park, NC, July, 1993.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Nitric Acid Manufacturing - Small Sources

Control Measure Name: Extended Absorption

Rule Name: Not Applicable

Pechan Measure Code: N0291S, N02901

POD: 29

Application: This control is the use of extended absorption technologies to reduce NO_x emissions.

This control applies to nitric acid manufacturing operations classified under SCCs 30101301, 30101302.

Affected SCC:

30101301 Chemical Manufacturing, Nitric Acid, Absorber Tail Gas (Pre-1970 Facilities)

30101302 Chemical Manufacturing, Nitric Acid, Absorber Tail Gas (Post-1970 Facilities)

Pollutant(s)	PM10	PM2.5	EC	OC	NO _x	VOC	SO ₂	NH ₃	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 95% from uncontrolled

Equipment Life: 10 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The basis of the costs are model plant data contained in the Alternative Control Techniques (ACT) document (EPA, 1991). Capital and annual cost information was obtained from control-specific cost data, allowing for the back calculation of operating and maintenance costs. From these determinations, default cost per ton values were assigned (Pechan, 1998). A capital cost to annual cost ratio of 8.1 was developed to estimate default capital and operating and maintenance costs. A discount rate of 10% was assumed for all sources. The equipment life was assumed to be 10 years.

O&M Cost Components: The O&M cost breakdown is estimated using the detailed information in Tables 6-1 and 6-2 of the Nitric and Adipic Acid Manufacturing Plant ACT document. The breakdown was obtained using O&M costs for a 500 ton per day plant. A capacity factor of 0.5 is used in estimating the O&M cost breakdown.

Operating labor: \$22.00 per man-hr

Operating labor – supervision: 20% of operating labor

Maintenance materials and labor: 4% of capital cost

Electricity: \$0.06 per kw-hr

Water: \$0.74 per 1000 gallon

Cost Effectiveness: The default cost effectiveness value used in AirControlNET is \$480 per ton NO_x reduced from both uncontrolled and RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 1998

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

References:

EPA, 1991: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- Nitric and Adipic Acid Manufacturing Plants," EPA-450/3-91-026, Research Triangle Park, NC, January 1991.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 1998.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Nitric Acid Manufacturing - Small Sources

Control Measure Name: Selective Catalytic Reduction (SCR)

Rule Name: Not Applicable

Pechan Measure Code: N0292S, N02902

POD: 29

Application: This control is the selective catalytic reduction of NO_x through add-on controls. SCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NO_x) into molecular nitrogen (N₂) and water vapor (H₂O). The SCR utilizes a catalyst to increase the NO_x removal efficiency, which allows the process to occur at lower temperatures.

Applies to nitric acid manufacturing operations with NO_x emissions greater than 10 tons per year.

Affected SCC:

30101301 Chemical Manufacturing, Nitric Acid, Absorber Tail Gas (Pre-1970 Facilities)

30101302 Chemical Manufacturing, Nitric Acid, Absorber Tail Gas (Post-1970 Facilities)

Pollutant(s)	PM10	PM2.5	EC	OC	NO _x	VOC	SO ₂	NH ₃	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 97% from uncontrolled

Equipment Life: 10 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NO_x emission levels (Pechan, 1998).

Small source = emission levels less than 1 ton per ozone season day

Large source = emission levels greater than 1 ton per ozone season day

Costs for stationary source NO_x control are based on an analysis of EPA's NO_x State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 10 years (EPA, 1991).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than 70% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown is estimated using the detailed information in Table 6-7 and Ch. 6 of the Nitric and Adipic Acid Manufacturing Plant ACT document. The breakdown was obtained using the average O&M costs for three plants having capacities of 200, 500 and 1000 tons per day.

Maintenance materials and labor: 4% of capital cost

Cost Effectiveness: The cost effectiveness value (for both small and large sources) used in AirControlNET is \$590 per ton NO_x reduced from both uncontrolled and RACT

AT-A-GLANCE TABLE FOR POINT SOURCES

baselines (1990\$).

Comments:

Status: Demonstrated	Last Reviewed: 2001
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Additional Information:

Selective Catalytic Reduction (SCR) has been widely applied to stationary source, fossil fuel-fired, combustion units for emission control since the early 1970s. SCR is typically implemented on units requiring a higher level of NO_x control than achievable by SNCR or other combustion controls (EPA, 2002).

Like SNCR, SCR is based on the chemical reduction of the NO_x molecule. The primary difference between SNCR and SCR is that SCR uses a metal-based catalyst to increase the rate of reaction (EPA, 2002). A nitrogen based reducing reagent, such as ammonia or urea, is injected into the flue gas. The reagent reacts selectively with the flue gas NO_x within a specific temperature range and in the presence of the catalyst and oxygen to reduce the NO_x.

The use of a catalyst results in two advantages of the SCR process over SNCR, the higher NO_x reduction efficiency and the lower and broader temperature ranges. However, the decrease in reaction temperature and increase in efficiency is accompanied by a significant increase in capital and operating costs (EPA, 2002). The cost increase is due to the large amount of catalyst required.

The SCR system can utilize either aqueous or anhydrous ammonia as the reagent. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Today, catalyst formulations include single component, multi-component, or active phase with a support structure. Most catalyst formulations contain additional compounds or supports, providing thermal and structural stability or to increase surface area (EPA, 2002).

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include: reaction temperature range; residence time available in the optimum temperature range; degree of mixing between the injected reagent and the combustion gases; uncontrolled NO_x concentration level; molar ratio of injected reagent to uncontrolled NO_x; ammonia slip; catalyst activity; catalyst selectivity; pressure drop across the catalyst; catalyst pitch; catalyst deactivation; and catalyst management (EPA, 2001).

References:

EPA, 1991: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- Nitric and Adipic Acid Manufacturing Plants," EPA-450/3-91-026, Research Triangle Park, NC, January 1991.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

AT-A-GLANCE TABLE FOR POINT SOURCES

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Nitric Acid Manufacturing - Small Sources

Control Measure Name: Non-Selective Catalytic Reduction (NSCR)

Rule Name: Not Applicable

Pechan Measure Code: N0293S, N029036

POD: 29

Application: This control is the reduction of NO_x emission through selective non-catalytic reduction add-on controls. SNCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NO_x) into molecular nitrogen (N₂) and water vapor (H₂O).

This control applies to nitric acid manufacturing operations with uncontrolled NO_x emissions greater than 10 tons per year. These sources are classified under SCCs 30101301 and 30101302.

Affected SCC:

30101301 Chemical Manufacturing, Nitric Acid, Absorber Tail Gas (Pre-1970 Facilities)

30101302 Chemical Manufacturing, Nitric Acid, Absorber Tail Gas (Post-1970 Facilities)

Pollutant(s)	PM10	PM2.5	EC	OC	NO _x	VOC	SO ₂	NH ₃	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 98% from uncontrolled

Equipment Life: 10 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NO_x emission levels (Pechan, 1998).

Small source = emission levels less than 1 ton per ozone season day

Large source = emission levels greater than 1 ton per ozone season day

Costs for stationary source NO_x control are based on an analysis of EPA's NO_x State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned for small sources. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 10 years (EPA, 1991).

O&M Cost Components: The O&M cost breakdown is estimated using the detailed information in Table 6-4 and Ch. 6 of the Nitric and Adipic Acid Manufacturing Plant ACT document. The breakdown was obtained using O&M costs for three plants having capacities of 200, 500 and 1000 tons per day.

Maintenance materials and labor: 4% of capital cost

Operating labor – direct: \$22 per hour

Operating labor – supervision: 20% of direct operating labor

Fuel (natural gas): \$4.12 per MMBTU

Cost Effectiveness: The cost effectiveness (for both small and large sources) used in

AT-A-GLANCE TABLE FOR POINT SOURCES

AirControlNET for both reductions from baseline and reductions from RACT is \$550 per ton NO_x reduced (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

SNCR is the reduction of NO_x in flue gas to N₂ and water vapor. This reduction is done with a nitrogen based reducing reagent, such as ammonia or urea. The reagent can react with a number of flue gas components. However, the NO_x reduction reaction is favored for a specific temperature range and in the presence of oxygen (EPA, 2002).

Both ammonia and urea are used as reagents. The cost of the reagent represents a large part of the annual costs of an SNCR system. Ammonia is generally less expensive than urea. However, the choice of reagent is also based on physical properties and operational considerations (EPA, 2002).

Ammonia can be utilized in either aqueous or anhydrous form. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Urea based systems have several advantages, including several safety aspects. Urea is a nontoxic, less volatile liquid that can be stored and handled more safely than ammonia. Urea solution droplets can penetrate farther into the flue gas when injected into the boiler, enhancing mixing (EPA, 2002). Because of these advantages, urea is more commonly used than ammonia in large boiler applications.

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include:

Reaction temperature range;

Residence time available in the optimum temperature range;

Degree of mixing between the injected reagent and the combustion gases

Uncontrolled NO_x concentration level;

Molar ratio of injected reagent to uncontrolled NO_x ; and ammonia slip.

References:

EPA, 1991: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- Nitric and Adipic Acid Manufacturing Plants," EPA-450/3-91-026, Research Triangle Park, NC, January 1991.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

AT-A-GLANCE TABLE FOR NONROAD SOURCES

Source Category: Off-Highway Diesel Vehicles

Control Measure Name: Final Compression-Ignition (C-I) Engine Standards

Rule Name: Final Compression-Ignition (C-I) Engine Standards

Pechan Measure Code: CI2010

POD: N/A

Application: This control measure represents the application of EPA's Federal Tier 1/Tier2/Tier 3 C-I standards to diesel equipment to model implementation of these standards for 2010.

This control measure applies to non-road diesel vehicles, including railroad equipment.

Affected SCC:

2270001000 Off-highway Vehicle Diesel; Recreational Equipment
2270002000 Off-highway Vehicle Diesel; Construction and Mining Equipment
2270003000 Off-highway Vehicle Diesel; Industrial Equipment
2270004000 Off-highway Vehicle Diesel; Lawn and Garden Equipment
2270005000 Off-highway Vehicle Diesel; Agricultural Equipment
2270006000 Off-highway Vehicle Diesel; Commercial Equipment
2270007000 Off-highway Vehicle Diesel; Logging Equipment
2270008000 Off-highway Vehicle Diesel; Airport Ground Support Equipment
2285002015 Railroad Equipment; Diesel; Railway Maintenance

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√	√			√*	√			√	

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: The control efficiency varies by equipment category: PM2.5 (22-50%); PM10 (22-50%); NOx (14-49%); VOC (26-60%); CO (23-53%).

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: To calculate costs for the final nonroad C-I standards, an estimate was made of the number of affected engines by horsepower range and by Tier type (i.e., Tier 1, Tier 2, or Tier 3) for each implementation year (Pechan, 2003). Near-term costs per engine by horsepower range and Tier type, obtained from EPA 1994 and EPA 1998, were then applied to the corresponding number of affected engines and summed to obtain the total cost for this standard. The number of affected engines was determined by subtracting out growth in engines, and using turnover data compiled from EPA's NONROAD 2002 model.

All costs are in 1998 dollars.

Cost Effectiveness: The total cost of this control measure varies by equipment category and Tier from \$56 per engine for Tier 1 engines with less than 50 HP to \$5,195 per engine for Tier 3 engines with 600 to 750 HP (\$1998).

Comments:

Status: Demonstrated

Last Reviewed: 2003

Additional Information:

AT-A-GLANCE TABLE FOR NONROAD SOURCES

References:

EPA, 1994: U.S. Environmental Protection Agency, Office of Mobile Sources, Certification Division, "Regulatory Impact Analysis and Regulatory Support Document, Control of Air Pollution; Determination of Significance for Nonroad Sources and Emission Standards for New Nonroad Compression-Ignition Engines at or Above 37 Kilowatts (50 Horsepower)," FINAL, Ann Arbor, MI. May 1994.

EPA, 1998: U.S. Environmental Protection Agency, Office of Air and Radiation, Office of Mobile Sources, "Final Regulatory Impact Analysis: Control of Emissions from Nonroad Diesel Engines," EPA420-R-98-016, August 1998.

Pechan, 2003: E.H. Pechan & Associates, Inc., "AirControlNET Development Report," Draft Report, prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, Pechan Report No. 03.08.002/9010.242, August 2003.

AT-A-GLANCE TABLE FOR NONROAD SOURCES

Source Category: Off-Highway Diesel Vehicles

Control Measure Name: Final Compression-Ignition (C-I) Engine Standards

Rule Name: Final Compression-Ignition (C-I) Engine Standards

Pechan Measure Code: CI2015

POD: N/A

Application: This control measure represents the application of EPA's Federal Tier 1/Tier2/Tier 3 C-I standards to diesel equipment to model implementation of these standards for 2015.

This control measure applies to non-road diesel vehicles, including railroad equipment.

Affected SCC:

2270001000 Off-highway Vehicle Diesel; Recreational Equipment
2270002000 Off-highway Vehicle Diesel; Construction and Mining Equipment
2270003000 Off-highway Vehicle Diesel; Industrial Equipment
2270004000 Off-highway Vehicle Diesel; Lawn and Garden Equipment
2270005000 Off-highway Vehicle Diesel; Agricultural Equipment
2270006000 Off-highway Vehicle Diesel; Commercial Equipment
2270007000 Off-highway Vehicle Diesel; Logging Equipment
2270008000 Off-highway Vehicle Diesel; Airport Ground Support Equipment
2285002015 Railroad Equipment; Diesel; Railway Maintenance

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√	√			√*	√			√	

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: The control efficiency varies by equipment category: PM2.5 (33-59%); PM10 (33-59%); NOx (34-57%); VOC (38-71%); CO (34-57%).

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: To calculate costs for the final nonroad C-I standards, an estimate was made of the number of affected engines by horsepower range and by Tier type (i.e., Tier 1, Tier 2, or Tier 3) for each implementation year (Pechan, 2003). Near-term costs per engine by horsepower range and Tier type, obtained from EPA 1994 and EPA 1998, were then applied to the corresponding number of affected engines and summed to obtain the total cost for this standard. The number of affected engines was determined by subtracting out growth in engines, and using turnover data compiled from EPA's NONROAD 2002 model.

All costs are in 1998 dollars.

Cost Effectiveness: The total cost of this control measure varies by equipment category and Tier from \$56 per engine for Tier 1 engines with less than 50 HP to \$5,195 per engine for Tier 3 engines with 600 to 750 HP (\$1998).

Comments:

Status: Demonstrated

Last Reviewed: 2003

Additional Information:

AT-A-GLANCE TABLE FOR NONROAD SOURCES

References:

EPA, 1994: U.S. Environmental Protection Agency, Office of Mobile Sources, Certification Division, "Regulatory Impact Analysis and Regulatory Support Document, Control of Air Pollution; Determination of Significance for Nonroad Sources and Emission Standards for New Nonroad Compression-Ignition Engines at or Above 37 Kilowatts (50 Horsepower)," FINAL, Ann Arbor, MI. May 1994.

EPA, 1998: U.S. Environmental Protection Agency, Office of Air and Radiation, Office of Mobile Sources, "Final Regulatory Impact Analysis: Control of Emissions from Nonroad Diesel Engines," EPA420-R-98-016, August 1998.

Pechan, 2003: E.H. Pechan & Associates, Inc., "AirControlNET Development Report," Draft Report, prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, Pechan Report No. 03.08.002/9010.242, August 2003.

AT-A-GLANCE TABLE FOR NONROAD SOURCES

Source Category: Off-Highway Diesel Vehicles

Control Measure Name: Final Compression-Ignition (C-I) Engine Standards

Rule Name: Final Compression-Ignition (C-I) Engine Standards

Pechan Measure Code: CI2020

POD: N/A

Application: This control measure represents the application of EPA's Federal Tier 1/Tier2/Tier 3 C-I standards to diesel equipment to model implementation of these standards for 2020.

This control measure applies to non-road diesel vehicles, including railroad equipment.

Affected SCC:

2270001000 Off-highway Vehicle Diesel; Recreational Equipment
2270002000 Off-highway Vehicle Diesel; Construction and Mining Equipment
2270003000 Off-highway Vehicle Diesel; Industrial Equipment
2270004000 Off-highway Vehicle Diesel; Lawn and Garden Equipment
2270005000 Off-highway Vehicle Diesel; Agricultural Equipment
2270006000 Off-highway Vehicle Diesel; Commercial Equipment
2270007000 Off-highway Vehicle Diesel; Logging Equipment
2270008000 Off-highway Vehicle Diesel; Airport Ground Support Equipment
2285002015 Railroad Equipment; Diesel; Railway Maintenance

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√	√			√*	√			√	

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: The control efficiency varies by equipment category: PM2.5 (37-66%); PM10 (37-66%); NOx (28-64%); VOC (49-75%); CO (28-64%).

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: To calculate costs for the final nonroad C-I standards, an estimate was made of the number of affected engines by horsepower range and by Tier type (i.e., Tier 1, Tier 2, or Tier 3) for each implementation year (Pechan, 2003). Near-term costs per engine by horsepower range and Tier type, obtained from EPA 1994 and EPA 1998, were then applied to the corresponding number of affected engines and summed to obtain the total cost for this standard. The number of affected engines was determined by subtracting out growth in engines, and using turnover data compiled from EPA's NONROAD 2002 model.

All costs are in 1998 dollars.

Cost Effectiveness: The total cost of this control measure varies by equipment category and Tier from \$56 per engine for Tier 1 engines with less than 50 HP to \$5,195 per engine for Tier 3 engines with 600 to 750 HP (\$1998).

Comments:

Status: Demonstrated

Last Reviewed: 2003

Additional Information:

AT-A-GLANCE TABLE FOR NONROAD SOURCES

References:

EPA, 1994: U.S. Environmental Protection Agency, Office of Mobile Sources, Certification Division, "Regulatory Impact Analysis and Regulatory Support Document, Control of Air Pollution; Determination of Significance for Nonroad Sources and Emission Standards for New Nonroad Compression-Ignition Engines at or Above 37 Kilowatts (50 Horsepower)," FINAL, Ann Arbor, MI. May 1994.

EPA, 1998: U.S. Environmental Protection Agency, Office of Air and Radiation, Office of Mobile Sources, "Final Regulatory Impact Analysis: Control of Emissions from Nonroad Diesel Engines," EPA420-R-98-016, August 1998.

Pechan, 2003: E.H. Pechan & Associates, Inc., "AirControlNET Development Report," Draft Report, prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, Pechan Report No. 03.08.002/9010.242, August 2003.

AT-A-GLANCE TABLE FOR NONROAD SOURCES

Source Category: Off-Highway Diesel Vehicles

Control Measure Name: Final Compression-Ignition (C-I) Engine Standards

Rule Name: Final Compression-Ignition (C-I) Engine Standards

Pechan Measure Code: CI2030

POD: N/A

Application: This control measure represents the application of EPA's Federal Tier 1/Tier2/Tier 3 C-I standards to diesel equipment to model implementation of these standards for 2030.

This control measure applies to non-road diesel vehicles, including railroad equipment.

Affected SCC:

2270001000 Off-highway Vehicle Diesel; Recreational Equipment
2270002000 Off-highway Vehicle Diesel; Construction and Mining Equipment
2270003000 Off-highway Vehicle Diesel; Industrial Equipment
2270004000 Off-highway Vehicle Diesel; Lawn and Garden Equipment
2270005000 Off-highway Vehicle Diesel; Agricultural Equipment
2270006000 Off-highway Vehicle Diesel; Commercial Equipment
2270007000 Off-highway Vehicle Diesel; Logging Equipment
2270008000 Off-highway Vehicle Diesel; Airport Ground Support Equipment
2285002015 Railroad Equipment; Diesel; Railway Maintenance

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√	√			√*	√			√	

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: The control efficiency varies by equipment category: PM2.5 (37-66%); PM10 (37-66%); NOx (41-66%); VOC (65-79%); CO (38-66%).

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: To calculate costs for the final nonroad C-I standards, an estimate was made of the number of affected engines by horsepower range and by Tier type (i.e., Tier 1, Tier 2, or Tier 3) for each implementation year (Pechan, 2003). Near-term costs per engine by horsepower range and Tier type, obtained from EPA 1994 and EPA 1998, were then applied to the corresponding number of affected engines and summed to obtain the total cost for this standard. The number of affected engines was determined by subtracting out growth in engines, and using turnover data compiled from EPA's NONROAD 2002 model.

All costs are in 1998 dollars.

Cost Effectiveness: The total cost of this control measure varies by equipment category and Tier from \$56 per engine for Tier 1 engines with less than 50 HP to \$5,195 per engine for Tier 3 engines with 600 to 750 HP (\$1998).

Comments:

Status: Demonstrated

Last Reviewed: 2003

Additional Information:

AT-A-GLANCE TABLE FOR NONROAD SOURCES

References:

EPA, 1994: U.S. Environmental Protection Agency, Office of Mobile Sources, Certification Division, "Regulatory Impact Analysis and Regulatory Support Document, Control of Air Pollution; Determination of Significance for Nonroad Sources and Emission Standards for New Nonroad Compression-Ignition Engines at or Above 37 Kilowatts (50 Horsepower)," FINAL, Ann Arbor, MI. May 1994.

EPA, 1998: U.S. Environmental Protection Agency, Office of Air and Radiation, Office of Mobile Sources, "Final Regulatory Impact Analysis: Control of Emissions from Nonroad Diesel Engines," EPA420-R-98-016, August 1998.

Pechan, 2003: E.H. Pechan & Associates, Inc., "AirControlNET Development Report," Draft Report, prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, Pechan Report No. 03.08.002/9010.242, August 2003.

AT-A-GLANCE TABLE FOR NONROAD SOURCES

Source Category: Off-Highway Gasoline Vehicles

Control Measure Name: Large Spark-Ignition (S-I) Engine Standards

Rule Name: Large Spark-Ignition (S-I) Engine Standards

Pechan Measure Code: SI2010

POD: N/A

Application: This control measure is the application of EPA's Federal exhaust standards for large S-I engines greater than 25 horsepower for implementation year 2010. These engines include 2-stroke gasoline, 4-stroke gasoline, liquified petroleum gasoline (LPG), and compressed natural gas (CNG).

Affected SCC:

2260001060 Off-highway Vehicle Gasoline, 2-Stroke; Recreational Equipment; Specialty Vehicles/Carts
2260006000 Off-highway Vehicle Gasoline, 2-Stroke; Commercial Equipment
2265001060 Off-highway Vehicle Gasoline, 4-Stroke; Recreational Equipment; Specialty Vehicles/Carts
2265002000 Off-highway Vehicle Gasoline, 4-Stroke; Construction and Mining Equipment
2265004000 Off-highway Vehicle Gasoline, 4-Stroke; Lawn and Garden Equipment
2265005000 Off-highway Vehicle Gasoline, 4-Stroke; Agricultural Equipment
2265006000 Off-highway Vehicle Gasoline, 4-Stroke; Commercial Equipment
2265008000 Off-highway Vehicle Gasoline, 4-Stroke; Airport Ground Support Equipment
2267001060 Off-highway Vehicle LPG; Recreational Equipment; Specialty Vehicles/Carts
2267002000 Off-highway Vehicle LPG; Construction and Mining Equipment
2267003000 Off-highway Vehicle LPG; Industrial Equipment
2267004000 Off-highway Vehicle LPG; Lawn and Garden Equipment
2267005000 Off-highway Vehicle LPG; Agricultural Equipment
2267006000 Off-highway Vehicle LPG; Commercial Equipment
2267008000 Off-highway Vehicle LPG; Airport Ground Support Equipment
2268002000 Off-highway Vehicle CNG; Construction and Mining Equipment
2268005000 Off-highway Vehicle CNG; Agricultural Equipment
2268006000 Off-highway Vehicle CNG; Commercial Equipment
2285004015 Railroad Equipment; Gasoline, 4-Stroke; Railway Maintenance
2285006015 Railroad Equipment; LPG; Railway Maintenance

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√	√			√*	√			√	

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: The control efficiency varies by equipment category: PM2.5 (Increase-7%); PM10 (Increase-7%); NOx (Increase-77%); VOC (1-78%); CO (1-75%).

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: To calculate costs for the nonroad large S-I standards, an estimate was made of the number of affected engines by Phase for each implementation year (Pechan, 2003). Near-term costs per engine by Phase, obtained from EPA 2002, were then applied to the corresponding number of affected engines and summed to obtain the total cost for this standard. The number of affected engines was determined by subtracting out

AT-A-GLANCE TABLE FOR NONROAD SOURCES

growth in engines, and using turnover data compiled from EPA's NONROAD 2002 model.

All costs are in 2001 dollars.

Cost Effectiveness: The cost of S-I engines varies by Phase, technology type and equipment category from \$550 to \$847 per engine (\$2001).

Comments:

Status: Demonstrated

Last Reviewed: 2003

Additional Information:

References:

EPA, 2002: U.S. Environmental Protection Agency, Office of Air and Radiation, Office of Transportation and Air Quality, "Final Regulatory Support Document: Control of Emissions from Unregulated Nonroad Engines," EPA420-R-02-022, September 2002.

Pechan, 2003: E.H. Pechan & Associates, Inc., "AirControlNET Development Report," Draft Report, prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, Pechan Report No. 03.08.002/9010.242, August 2003.

AT-A-GLANCE TABLE FOR NONROAD SOURCES

Source Category: Off-Highway Gasoline Vehicles

Control Measure Name: Large Spark-Ignition (S-I) Engine Standards

Rule Name: Large Spark-Ignition (S-I) Engine Standards

Pechan Measure Code: SI2015

POD: N/A

Application: This control measure is the application of EPA's Federal exhaust standards for large S-I engines greater than 25 horsepower for implementation year 2015. These engines include 2-stroke gasoline, 4-stroke gasoline, liquified petroleum gasoline (LPG), and compressed natural gas (CNG).

Affected SCC:

2260001060 Off-highway Vehicle Gasoline, 2-Stroke; Recreational Equipment; Specialty Vehicles/Carts
2260006000 Off-highway Vehicle Gasoline, 2-Stroke; Commercial Equipment
2265001060 Off-highway Vehicle Gasoline, 4-Stroke; Recreational Equipment; Specialty Vehicles/Carts
2265002000 Off-highway Vehicle Gasoline, 4-Stroke; Construction and Mining Equipment
2265004000 Off-highway Vehicle Gasoline, 4-Stroke; Lawn and Garden Equipment
2265005000 Off-highway Vehicle Gasoline, 4-Stroke; Agricultural Equipment
2265006000 Off-highway Vehicle Gasoline, 4-Stroke; Commercial Equipment
2265008000 Off-highway Vehicle Gasoline, 4-Stroke; Airport Ground Support Equipment
2267001060 Off-highway Vehicle LPG; Recreational Equipment; Specialty Vehicles/Carts
2267002000 Off-highway Vehicle LPG; Construction and Mining Equipment
2267003000 Off-highway Vehicle LPG; Industrial Equipment
2267004000 Off-highway Vehicle LPG; Lawn and Garden Equipment
2267005000 Off-highway Vehicle LPG; Agricultural Equipment
2267006000 Off-highway Vehicle LPG; Commercial Equipment
2267008000 Off-highway Vehicle LPG; Airport Ground Support Equipment
2268002000 Off-highway Vehicle CNG; Construction and Mining Equipment
2268005000 Off-highway Vehicle CNG; Agricultural Equipment
2268006000 Off-highway Vehicle CNG; Commercial Equipment
2285004015 Railroad Equipment; Gasoline, 4-Stroke; Railway Maintenance
2285006015 Railroad Equipment; LPG; Railway Maintenance

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√	√			√*	√			√	

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: The control efficiency varies by equipment category: PM2.5 (Increase-7%); PM10 (Increase-7%); NOx (Increase-91%); VOC (1-93%); CO (1-87%).

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: To calculate costs for the nonroad large S-I standards, an estimate was made of the number of affected engines by Phase for each implementation year (Pechan, 2003). Near-term costs per engine by Phase, obtained from EPA 2002, were then applied to the corresponding number of affected engines and summed to obtain the total cost for this standard. The number of affected engines was determined by subtracting out

AT-A-GLANCE TABLE FOR NONROAD SOURCES

growth in engines, and using turnover data compiled from EPA's NONROAD 2002 model.

All costs are in 2001 dollars.

Cost Effectiveness: The cost of S-I engines varies by Phase, technology type and equipment category from \$550 to \$847 per engine (\$2001).

Comments:

Status: Demonstrated

Last Reviewed: 2003

Additional Information:

References:

EPA, 2002: U.S. Environmental Protection Agency, Office of Air and Radiation, Office of Transportation and Air Quality, "Final Regulatory Support Document: Control of Emissions from Unregulated Nonroad Engines," EPA420-R-02-022, September 2002.

Pechan, 2003: E.H. Pechan & Associates, Inc., "AirControlNET Development Report," Draft Report, prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, Pechan Report No. 03.08.002/9010.242, August 2003.

AT-A-GLANCE TABLE FOR NONROAD SOURCES

Source Category: Off-Highway Gasoline Vehicles

Control Measure Name: Large Spark-Ignition (S-I) Engine Standards

Rule Name: Large Spark-Ignition (S-I) Engine Standards

Pechan Measure Code: SI2020

POD: N/A

Application: This control measure is the application of EPA's Federal exhaust standards for large S-I engines greater than 25 horsepower for implementation year 2020. These engines include 2-stroke gasoline, 4-stroke gasoline, liquified petroleum gasoline (LPG), and compressed natural gas (CNG).

Affected SCC:

2260001060 Off-highway Vehicle Gasoline, 2-Stroke; Recreational Equipment; Specialty Vehicles/Carts
2260006000 Off-highway Vehicle Gasoline, 2-Stroke; Commercial Equipment
2265001060 Off-highway Vehicle Gasoline, 4-Stroke; Recreational Equipment; Specialty Vehicles/Carts
2265002000 Off-highway Vehicle Gasoline, 4-Stroke; Construction and Mining Equipment
2265004000 Off-highway Vehicle Gasoline, 4-Stroke; Lawn and Garden Equipment
2265005000 Off-highway Vehicle Gasoline, 4-Stroke; Agricultural Equipment
2265006000 Off-highway Vehicle Gasoline, 4-Stroke; Commercial Equipment
2265008000 Off-highway Vehicle Gasoline, 4-Stroke; Airport Ground Support Equipment
2267001060 Off-highway Vehicle LPG; Recreational Equipment; Specialty Vehicles/Carts
2267002000 Off-highway Vehicle LPG; Construction and Mining Equipment
2267003000 Off-highway Vehicle LPG; Industrial Equipment
2267004000 Off-highway Vehicle LPG; Lawn and Garden Equipment
2267005000 Off-highway Vehicle LPG; Agricultural Equipment
2267006000 Off-highway Vehicle LPG; Commercial Equipment
2267008000 Off-highway Vehicle LPG; Airport Ground Support Equipment
2268002000 Off-highway Vehicle CNG; Construction and Mining Equipment
2268005000 Off-highway Vehicle CNG; Agricultural Equipment
2268006000 Off-highway Vehicle CNG; Commercial Equipment
2285004015 Railroad Equipment; Gasoline, 4-Stroke; Railway Maintenance
2285006015 Railroad Equipment; LPG; Railway Maintenance

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√	√			√*	√			√	

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: The control efficiency varies by equipment category: PM2.5 (Increase-6%); PM10 (Increase-6%); NOx (Increase-93%); VOC (1-95%); CO (1-90%).

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: To calculate costs for the nonroad large S-I standards, an estimate was made of the number of affected engines by Phase for each implementation year (Pechan, 2003). Near-term costs per engine by Phase, obtained from EPA 2002, were then applied to the corresponding number of affected engines and summed to obtain the total cost for this standard. The number of affected engines was determined by subtracting out

AT-A-GLANCE TABLE FOR NONROAD SOURCES

growth in engines, and using turnover data compiled from EPA's NONROAD 2002 model.

All costs are in 2001 dollars.

Cost Effectiveness: The cost of S-I engines varies by Phase, technology type and equipment category from \$550 to \$847 per engine (\$2001).

Comments:

Status: Demonstrated

Last Reviewed: 2003

Additional Information:

References:

EPA, 2002: U.S. Environmental Protection Agency, Office of Air and Radiation, Office of Transportation and Air Quality, "Final Regulatory Support Document: Control of Emissions from Unregulated Nonroad Engines," EPA420-R-02-022, September 2002.

Pechan, 2003: E.H. Pechan & Associates, Inc., "AirControlNET Development Report," Draft Report, prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, Pechan Report No. 03.08.002/9010.242, August 2003.

AT-A-GLANCE TABLE FOR NONROAD SOURCES

Source Category: Off-Highway Gasoline Vehicles

Control Measure Name: Large Spark-Ignition (S-I) Engine Standards

Rule Name: Large Spark-Ignition (S-I) Engine Standards

Pechan Measure Code: SI2030

POD: N/A

Application: This control measure is the application of EPA's Federal exhaust standards for large S-I engines greater than 25 horsepower for implementation year 2030. These engines include 2-stroke gasoline, 4-stroke gasoline, liquified petroleum gasoline (LPG), and compressed natural gas (CNG).

Affected SCC:

2260001060 Off-highway Vehicle Gasoline, 2-Stroke; Recreational Equipment; Specialty Vehicles/Carts
 2260006000 Off-highway Vehicle Gasoline, 2-Stroke; Commercial Equipment
 2265001060 Off-highway Vehicle Gasoline, 4-Stroke; Recreational Equipment; Specialty Vehicles/Carts
 2265002000 Off-highway Vehicle Gasoline, 4-Stroke; Construction and Mining Equipment
 2265004000 Off-highway Vehicle Gasoline, 4-Stroke; Lawn and Garden Equipment
 2265005000 Off-highway Vehicle Gasoline, 4-Stroke; Agricultural Equipment
 2265006000 Off-highway Vehicle Gasoline, 4-Stroke; Commercial Equipment
 2265008000 Off-highway Vehicle Gasoline, 4-Stroke; Airport Ground Support Equipment
 2267001060 Off-highway Vehicle LPG; Recreational Equipment; Specialty Vehicles/Carts
 2267002000 Off-highway Vehicle LPG; Construction and Mining Equipment
 2267003000 Off-highway Vehicle LPG; Industrial Equipment
 2267004000 Off-highway Vehicle LPG; Lawn and Garden Equipment
 2267005000 Off-highway Vehicle LPG; Agricultural Equipment
 2267006000 Off-highway Vehicle LPG; Commercial Equipment
 2267008000 Off-highway Vehicle LPG; Airport Ground Support Equipment
 2268002000 Off-highway Vehicle CNG; Construction and Mining Equipment
 2268005000 Off-highway Vehicle CNG; Agricultural Equipment
 2268006000 Off-highway Vehicle CNG; Commercial Equipment
 2285004015 Railroad Equipment; Gasoline, 4-Stroke; Railway Maintenance
 2285006015 Railroad Equipment; LPG; Railway Maintenance

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√	√			√*	√			√	

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: The control efficiency varies by equipment category: PM2.5 (0-6%); PM10 (0-6%); NOx (Increase-93%); VOC (1-90%); CO (0-90%).

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: To calculate costs for the nonroad large S-I standards, an estimate was made of the number of affected engines by Phase for each implementation year (Pechan, 2003). Near-term costs per engine by Phase, obtained from EPA 2002, were then applied to the corresponding number of affected engines and summed to obtain the total cost for this standard. The number of affected engines was determined by subtracting out

AT-A-GLANCE TABLE FOR NONROAD SOURCES

growth in engines, and using turnover data compiled from EPA's NONROAD 2002 model.

All costs are in 2001 dollars.

Cost Effectiveness: The cost of S-I engines varies by Phase, technology type and equipment category from \$550 to \$847 per engine (\$2001).

Comments:

Status: Demonstrated

Last Reviewed: 2003

Additional Information:

References:

EPA, 2002: U.S. Environmental Protection Agency, Office of Air and Radiation, Office of Transportation and Air Quality, "Final Regulatory Support Document: Control of Emissions from Unregulated Nonroad Engines," EPA420-R-02-022, September 2002.

Pechan, 2003: E.H. Pechan & Associates, Inc., "AirControlNET Development Report," Draft Report, prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, Pechan Report No. 03.08.002/9010.242, August 2003.

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Open Burning

Control Measure Name: Episodic Ban (Daily Only)

Rule Name: Not Applicable

Pechan Measure Code: N12201

POD: 122

Application: This is a generic control measure that would ban open burning on days where ozone exceedances were predicted, reducing NOx emissions on those days. This measure would not reduce the annual emissions.

Affected SCC:

2610000000 Open Burning

2610010000 Open Burning

2610020000 Open Burning

2610030000 Open Burning

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: Daily control efficiency is 100% from uncontrolled; Annual control efficiency is 0% from uncontrolled

Equipment Life: Not Applicable

Rule Effectiveness: 80%

Penetration: 100%

Cost Basis: Because burning can simply be shifted to other acceptable periods, emission control costs would be zero for regulations that shift the burning to days where ozone exceedances are not predicted (Pechan, 1996). Although this periodic ban would have no cost in the stationary source measures, a cost may be incurred in the area source total due to labor shifts.

Cost Effectiveness: The cost effectiveness associated with this control is \$0 per ton NOx reduced. (1990)

Note: Since this is a daily control, no annual emission reductions are expected.

Comments:

Status: Demonstrated

Last Reviewed: 1996

Additional Information:

Generally, the relatively low temperatures associated with open burning tend to suppress NOx emissions. Because of the relatively low level of NOx emissions expected to result from open burning, little attention has been paid to quantifying or controlling the NOx emissions from this source. However, some jurisdictions control open burning by limiting the types of material that can be burned, or, based on ambient conditions limiting the days on which materials can be burned.

Assuming full compliance with the regulation, daily NOx emission reductions from such a regulation would be 100% (Pechan, 1996). However, annual emission reductions would not be expected because there would likely be a shift in the timing of emissions, not a reduction in the total amount of

AT-A-GLANCE TABLE FOR AREA SOURCES

annual NOx emitted.

References:

Pechan, 1994: E.H. Pechan & Associates, Inc., "Analysis of Incremental Emission Reductions and Costs of VOC and NOx Control Measures," prepared for U.S. Environmental Protection Agency, Ambient Standards Branch, Research Triangle Park, NC, September 1994.

Pechan, 1996: E.H. Pechan & Associates, "The Emission Reduction and Cost Analysis Model for NOx (ECRAM-NOx)," Revised Documentation, prepared for U.S. Environmental Protection Agency, Ozone Policy and Strategies Group, Research Triangle Park, NC, September 1996.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Plastics Prod-Specific; (ABS) - Small Sources

Control Measure Name: Low NOx Burner + Flue Gas Recirculation

Rule Name: Not Applicable

Pechan Measure Code: N0632S, N06302

POD: 63

Application: This control is the use of low NOx burner (LNB) technology and flue gas recirculation (FGR) to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another.

This control is applicable to with acrylonitrile-butadiene-styrene plastic production uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

30101849 Plastics Production, Acrylonitrile-Butadiene-Styrene (ABS) Resin

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 55% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by power output (Pechan, 1998).

Small source = less than 1 ton NOx per ozone season day

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). The basis of the costs are model plant data in the Alternative Control Techniques (ACT) document (EPA, 1994). From this analysis, default cost per ton values are assigned along with a capital to annual costs ratio of 6.9. An equipment life of 15 years (EPA, 1994).

Cost Effectiveness: The default cost effectiveness values are \$3,190 per ton NOx reduced from uncontrolled and \$1,430 per ton NOx reduced from RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

It is assumed that the NOx source is a process heater or boiler.

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNBs create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion

AT-A-GLANCE TABLE FOR POINT SOURCES

zone. Staged-fuel LNBs create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Industrial/Commercial/Institutional (ICI) Boilers," EPA,-453/R-94-022, Research Triangle Park, NC, June 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Process Heaters - Distillate Oil - Small Sources

Control Measure Name: Low NOx Burner

Rule Name: Not Applicable

Pechan Measure Code: N0251S, N02501

POD: 25

Application: This control is the use of low NOx burner (LNB) technology to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another.

This control is applicable to small (40 to 174 MMBtu/hr) distillate oil-fired process heaters and uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

30190001 Fuel Fired Equipment, Distillate Oil (No. 2): Process Heaters
30590001 Fuel Fired Equipment, Distillate Oil (No. 2): Process Heaters
30600101 Process Heaters, Oil-fired **
30600103 Petroleum Industry, Process Heaters, Oil-fired
30600111 Process Heaters, Oil-fired (No. 6 Oil) > 100 Million Btu Capacity
30790001 Fuel Fired Equipment, Distillate Oil (No. 2): Process Heaters
39990001 Miscellaneous Manufacturing Industries, Distillate Oil (No. 2): Process Heaters

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 45% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by power output (Pechan, 1998).

Small source = 40 to 174 MMBtu/hr

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned along with a capital to annual costs ratio of 7.3. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 15 years (EPA, 1993).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 48% (Pechan, 2001).

Cost Effectiveness: The default cost effectiveness value used in AirControlINET is \$3,740 per ton NOx reduced from both uncontrolled and RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNBs create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNBs create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

References:

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Process Heaters," EPA-453/R-93-034, Research Triangle Park, NC, September 1993.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Process Heaters - Distillate Oil - Small Sources

Control Measure Name: Low NOx Burner + Flue Gas Recirculation

Rule Name: Not Applicable

Pechan Measure Code: N0252S, N02502

POD: 25

Application: This control is the use of low NOx burner (LNB) technology and flue gas recirculation (FGR) to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another.

This control is applicable to small (40 to 174 MMBtu/hr) distillate-fired process heaters with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

30190001 Fuel Fired Equipment, Distillate Oil (No. 2): Process Heaters

30590001 Fuel Fired Equipment, Distillate Oil (No. 2): Process Heaters

30600101 Process Heaters, Oil-fired **

30600103 Petroleum Industry, Process Heaters, Oil-fired

30600111 Process Heaters, Oil-fired (No. 6 Oil) > 100 Million Btu Capacity

30790001 Fuel Fired Equipment, Distillate Oil (No. 2): Process Heaters

39990001 Miscellaneous Manufacturing Industries, Distillate Oil (No. 2): Process Heaters

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 48% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by power output (Pechan, 1998).

Small source = 40 to 174 MMBtu/hr

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). The basis of the costs are model plant data in the Alternative Control Techniques (ACT) document (EPA, 1993). From this analysis, default cost per ton values are assigned along with a capital to annual costs ratio of 7.1. A discount rate of 10 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 15 years (EPA, 1993).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 48% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown is estimated using the detailed information in Table 6-4 and Ch. 6 of the Process Heaters ACT. The breakdown was obtained using the O&M costs for a mechanical draft process heater having a capacity of 69 MMBTU per hour. A capacity factor of 0.58 is used in estimating the

AT-A-GLANCE TABLE FOR POINT SOURCES

O&M cost breakdown.

Electricity: \$0.06 per kw-hr

Cost Effectiveness: The default cost effectiveness values are \$4,520 per ton NO_x reduced from uncontrolled and \$19,540 per ton NO_x reduced from RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNBs create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNBs create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

References:

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Process Heaters," EPA-453/R-93-034, Research Triangle Park, NC, September 1993.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Process Heaters - Distillate Oil - Small Sources

Control Measure Name: Selective Non-Catalytic Reduction (SNCR)

Rule Name: Not Applicable

Pechan Measure Code: N0253S, N02503

POD: 25

Application: This control is the reduction of NO_x emission through selective non-catalytic reduction add-on controls. SNCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NO_x) into molecular nitrogen (N₂) and water vapor (H₂O).

This control applies to small (<1 ton NO_x emissions per OSD) distillate oil-fired process heaters with uncontrolled NO_x emissions greater than 10 tons per year.

Affected SCC:

30190001 Fuel Fired Equipment, Distillate Oil (No. 2): Process Heaters
30590001 Fuel Fired Equipment, Distillate Oil (No. 2): Process Heaters
30600101 Process Heaters, Oil-fired **
30600103 Petroleum Industry, Process Heaters, Oil-fired
30600111 Process Heaters, Oil-fired (No. 6 Oil) > 100 Million Btu Capacity
30790001 Fuel Fired Equipment, Distillate Oil (No. 2): Process Heaters
39990001 Miscellaneous Manufacturing Industries, Distillate Oil (No. 2): Process Heaters

Pollutant(s)	PM10	PM2.5	EC	OC	NO _x	VOC	SO ₂	NH ₃	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 60% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NO_x emission levels (Pechan, 1998).

Small source = emission levels less than 1 ton per ozone season day

Costs for stationary source NO_x control are based on an analysis of EPA's NO_x State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned for small sources. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 15 years (EPA, 1993).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 48% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown is estimated using the detailed information in Table 6-4 and Ch. 6 of the Process Heaters ACT. The breakdown was obtained using the O&M costs for a mechanical draft process heater having a capacity of 69 MMBTU per hour. A capacity factor of 0.58 is used in estimating the O&M cost breakdown.

AT-A-GLANCE TABLE FOR POINT SOURCES

Electricity: \$0.06 per kw-hr
Fuel (distillate oil): \$5.54 per MMBTU
Ammonia: \$0.125 per lb

Cost Effectiveness: The cost effectiveness used in AirControlNET for both reductions from baseline and reductions from RACT is \$3,180 per ton NOx reduced (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

SNCR is the reduction of NOx in flue gas to N₂ and water vapor. This reduction is done with a nitrogen based reducing reagent, such as ammonia or urea. The reagent can react with a number of flue gas components. However, the NOx reduction reaction is favored for a specific temperature range and in the presence of oxygen (EPA, 2002).

Both ammonia and urea are used as reagents. The cost of the reagent represents a large part of the annual costs of an SNCR system. Ammonia is generally less expensive than urea. However, the choice of reagent is also based on physical properties and operational considerations (EPA, 2002).

Ammonia can be utilized in either aqueous or anhydrous form. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Urea based systems have several advantages, including several safety aspects. Urea is a nontoxic, less volatile liquid that can be stored and handled more safely than ammonia. Urea solution droplets can penetrate farther into the flue gas when injected into the boiler, enhancing mixing (EPA, 2002). Because of these advantages, urea is more commonly used than ammonia in large boiler applications.

The rate of reaction determines the amount of NOx removed from the flue gas. The important design and operational factors that affect the rate of reduction include:

Reaction temperature range;
Residence time available in the optimum temperature range;
Degree of mixing between the injected reagent and the combustion gases
Uncontrolled NOx concentration level;
Molar ratio of injected reagent to uncontrolled NOx ; and ammonia slip.

References:

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Process Heaters," EPA-453/R-93-034, Research Triangle Park, NC, September 1993.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air

AT-A-GLANCE TABLE FOR POINT SOURCES

Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Process Heaters - Distillate Oil - Small Sources

Control Measure Name: Ultra Low NOx Burner

Rule Name: Not Applicable

Pechan Measure Code: N0254S, N02504

POD: 25

Application: This control is the use of ultra-low NOx burner (ULNB) add-on technologies to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another. SCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NOx) into molecular nitrogen (N₂) and water vapor (H₂O).

This control applies to small (40 to 174 MMBtu/hr) distillate oil-fired process heaters with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

30190001 Fuel Fired Equipment, Distillate Oil (No. 2): Process Heaters

30590001 Fuel Fired Equipment, Distillate Oil (No. 2): Process Heaters

30600101 Process Heaters, Oil-fired **

30600103 Petroleum Industry, Process Heaters, Oil-fired

30600111 Process Heaters, Oil-fired (No. 6 Oil) > 100 Million Btu Capacity

30790001 Fuel Fired Equipment, Distillate Oil (No. 2): Process Heaters

39990001 Miscellaneous Manufacturing Industries, Distillate Oil (No. 2): Process Heaters

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 74% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by power output (Pechan, 1998).

Small source = 40 to 174 MMBtu/hr

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned along with a capital to annual costs ratio of 7.3. A discount rate of 10 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 15 years (EPA, 1993).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 48% (Pechan, 2001).

Cost Effectiveness: The default cost effectiveness value is \$2,140 per ton NOx reduced from both uncontrolled and RACT baselines (1990\$).

Comments:

AT-A-GLANCE TABLE FOR POINT SOURCES

Status: Demonstrated	Last Reviewed: 2001
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Additional Information:

LNBS are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNBS create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNBS create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

References:

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Process Heaters," EPA-453/R-93-034, Research Triangle Park, NC, September 1993.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Process Heaters - Distillate Oil - Small Sources

Control Measure Name: Selective Catalytic Reduction (SCR)

Rule Name: Not Applicable

Pechan Measure Code: N0255S, N02505

POD: 25

Application: This control is the selective catalytic reduction of NO_x through add-on controls. SCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NO_x) into molecular nitrogen (N₂) and water vapor (H₂O). The SCR utilizes a catalyst to increase the NO_x removal efficiency, which allows the process to occur at lower temperatures.

Applies to small (<1 ton NO_x per OSD) distillate oil-fired process heaters with NO_x emissions greater than 10 tons per year.

Affected SCC:

30190001 Fuel Fired Equipment, Distillate Oil (No. 2): Process Heaters

30590001 Fuel Fired Equipment, Distillate Oil (No. 2): Process Heaters

30600101 Process Heaters, Oil-fired **

30600103 Petroleum Industry, Process Heaters, Oil-fired

30600111 Process Heaters, Oil-fired (No. 6 Oil) > 100 Million Btu Capacity

30790001 Fuel Fired Equipment, Distillate Oil (No. 2): Process Heaters

39990001 Miscellaneous Manufacturing Industries, Distillate Oil (No. 2): Process Heaters

Pollutant(s)	PM10	PM2.5	EC	OC	NO _x	VOC	SO ₂	NH ₃	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 75% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NO_x emission levels (Pechan, 1998).

Small source = emission levels less than 1 ton per ozone season day

Costs for stationary source NO_x control are based on an analysis of EPA's NO_x State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 15 years (EPA, 1993).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 48% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown is estimated using the detailed information in Table 6-4 and Ch. 6 of the Process Heaters ACT. The breakdown was obtained using the O&M costs for a mechanical draft process heater having a capacity of 69 MMBTU per hour. A capacity factor of 0.58 is used in estimating the O&M cost breakdown.

AT-A-GLANCE TABLE FOR POINT SOURCES

Electricity: \$0.06 per kw-hr
Fuel (distillate oil): \$5.54 per MMBTU
Ammonia: \$0.125 per lb

Cost Effectiveness: The cost effectiveness value used in AirControlNET is \$9,230 per ton NO_x reduced from uncontrolled and RACT baselines (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

Selective Catalytic Reduction (SCR) has been widely applied to stationary source, fossil fuel-fired, combustion units for emission control since the early 1970s. SCR is typically implemented on units requiring a higher level of NO_x control than achievable by SNCR or other combustion controls (EPA, 2002).

Like SNCR, SCR is based on the chemical reduction of the NO_x molecule. The primary difference between SNCR and SCR is that SCR uses a metal-based catalyst to increase the rate of reaction (EPA, 2002). A nitrogen based reducing reagent, such as ammonia or urea, is injected into the flue gas. The reagent reacts selectively with the flue gas NO_x within a specific temperature range and in the presence of the catalyst and oxygen to reduce the NO_x.

The use of a catalyst results in two advantages of the SCR process over SNCR, the higher NO_x reduction efficiency and the lower and broader temperature ranges. However, the decrease in reaction temperature and increase in efficiency is accompanied by a significant increase in capital and operating costs (EPA, 2002). The cost increase is due to the large amount of catalyst required.

The SCR system can utilize either aqueous or anhydrous ammonia as the reagent. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Today, catalyst formulations include single component, multi-component, or active phase with a support structure. Most catalyst formulations contain additional compounds or supports, providing thermal and structural stability or to increase surface area (EPA, 2002).

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include: reaction temperature range; residence time available in the optimum temperature range; degree of mixing between the injected reagent and the combustion gases; uncontrolled NO_x concentration level; molar ratio of injected reagent to uncontrolled NO_x; ammonia slip; catalyst activity; catalyst selectivity; pressure drop across the catalyst; catalyst pitch; catalyst deactivation; and catalyst management (EPA, 2001).

References:

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Process Heaters," EPA-453/R-93-034, Research Triangle Park, NC, September 1993.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC,

AT-A-GLANCE TABLE FOR POINT SOURCES

January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Process Heaters - Distillate Oil - Small Sources

Control Measure Name: Low NOx Burner - Selective Non-Catalytic Reduction (SNCR)

Rule Name: Not Applicable

Pechan Measure Code: N0256S, N02506

POD: 25

Application: This control is the use of low NOx burner (LNB) technology and selective non catalytic reduction (SNCR) to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another. SNCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NOx) into molecular nitrogen (N2) and water vapor (H2O).

This control is applicable to small (40 to 174 MMBtu/hr) distillate oil-fired process heaters with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

30190001 Fuel Fired Equipment, Distillate Oil (No. 2): Process Heaters

30590001 Fuel Fired Equipment, Distillate Oil (No. 2): Process Heaters

30600101 Process Heaters, Oil-fired **

30600103 Petroleum Industry, Process Heaters, Oil-fired

30600111 Process Heaters, Oil-fired (No. 6 Oil) > 100 Million Btu Capacity

30790001 Fuel Fired Equipment, Distillate Oil (No. 2): Process Heaters

39990001 Miscellaneous Manufacturing Industries, Distillate Oil (No. 2): Process Heaters

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 78% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by power output (Pechan, 1998).

Small source = 40 to 174 MMBtu/hr

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). The basis of the costs are model plant data in the Alternative Control Techniques (ACT) document (EPA, 1993). From this analysis, default cost per ton values are assigned along with a capital to annual costs ratio of 6.5. A discount rate of 10 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 15 years (EPA, 1993).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 48% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown is estimated using the detailed information in Table 6-4 and Ch. 6 of the Process Heaters ACT. The breakdown was

AT-A-GLANCE TABLE FOR POINT SOURCES

obtained using the O&M costs for a mechanical draft process heater having a capacity of 69 MMBTU per hour. A capacity factor of 0.58 is used in estimating the O&M cost breakdown.

Electricity: \$0.06 per kw-hr

Fuel (distillate oil): \$5.54 per MMBTU

Ammonia: \$0.125 per lb

Cost Effectiveness: The default cost effectiveness values are \$3,620 per ton NO_x reduced from uncontrolled and \$3,830 per ton NO_x reduced from RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNB's create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNB's create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

SNCR is the reduction of NO_x in flue gas to N₂ and water vapor. This reduction is done with a nitrogen based reducing reagent, such as ammonia or urea. The reagent can react with a number of flue gas components. However, the NO_x reduction reaction is favored for a specific temperature range and in the presence of oxygen (EPA, 2002).

Both ammonia and urea are used as reagents. The cost of the reagent represents a large part of the annual costs of an SNCR system. Ammonia is generally less expensive than urea. However, the choice of reagent is also based on physical properties and operational considerations (EPA, 2002).

Ammonia can be utilized in either aqueous or anhydrous form. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Urea based systems have several advantages, including several safety aspects. Urea is a nontoxic, less volatile liquid that can be stored and handled more safely than ammonia. Urea solution droplets can penetrate farther into the flue gas when injected into the boiler, enhancing mixing (EPA, 2002). Because of these advantages, urea is more commonly used than ammonia in large boiler applications.

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include:

Reaction temperature range;

Residence time available in the optimum temperature range;

Degree of mixing between the injected reagent and the combustion gases

Uncontrolled NO_x concentration level;

Molar ratio of injected reagent to uncontrolled NO_x ; and ammonia slip.

AT-A-GLANCE TABLE FOR POINT SOURCES

References:

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Process Heaters," EPA,-453/R-93-034, Research Triangle Park, NC, September 1993.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Process Heaters - Distillate Oil - Small Sources

Control Measure Name: Low NOx Burner (LNB) + Selective Catalytic Reduction (SCR)

Rule Name: Not Applicable

Pechan Measure Code: N0257S, N02507

POD: 25

Application: This control is the use of low NOx burner (LNB) technology and selective catalytic reduction (SCR) to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another. SCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NOx) into molecular nitrogen (N₂) and water vapor (H₂O). The SCR utilizes a catalyst to increase the NOx removal efficiency, which allows the process to occur at lower temperatures.

This control is applicable to small (40 to 174 MMBtu/hr) distillate oil-fired process heaters with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

30190001 Fuel Fired Equipment, Distillate Oil (No. 2): Process Heaters

30590001 Fuel Fired Equipment, Distillate Oil (No. 2): Process Heaters

30600101 Process Heaters, Oil-fired **

30600103 Petroleum Industry, Process Heaters, Oil-fired

30600111 Process Heaters, Oil-fired (No. 6 Oil) > 100 Million Btu Capacity

30790001 Fuel Fired Equipment, Distillate Oil (No. 2): Process Heaters

39990001 Miscellaneous Manufacturing Industries, Distillate Oil (No. 2): Process Heaters

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 92% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by power output (Pechan, 1998).

Small source = 40 to 174 MMBtu/hr

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). The basis of the costs are model plant data in the Alternative Control Techniques (ACT) document (EPA, 1993). From this analysis, default cost per ton values are assigned along with a capital to annual costs ratio of 6.5. A discount rate of 10 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 15 years (EPA, 1993).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 48% (Pechan, 2001).

AT-A-GLANCE TABLE FOR POINT SOURCES

O&M Cost Components: The O&M cost breakdown is estimated using the detailed information in Table 6-4 and Ch. 6 of the Process Heaters ACT. The breakdown was obtained using the O&M costs for a mechanical draft process heater having a capacity of 69 MMBTU per hour. A capacity factor of 0.58 is used in estimating the O&M cost breakdown.

Electricity: \$0.06 per kw-hr

Fuel (distillate oil): \$5.54 per MMBTU

Ammonia: \$0.125 per lb

Cost Effectiveness: The default cost effectiveness values are \$9,120 per ton NO_x reduced from uncontrolled and \$15,350 per ton NO_x reduced from RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNB's create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNB's create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

Selective Catalytic Reduction (SCR) has been widely applied to stationary source, fossil fuel-fired, combustion units for emission control since the early 1970s. SCR is typically implemented on units requiring a higher level of NO_x control than achievable by SNCR or other combustion controls (EPA, 2002).

Like SNCR, SCR is based on the chemical reduction of the NO_x molecule. The primary difference between SNCR and SCR is that SCR uses a metal-based catalyst to increase the rate of reaction (EPA, 2002). A nitrogen based reducing reagent, such as ammonia or urea, is injected into the flue gas. The reagent reacts selectively with the flue gas NO_x within a specific temperature range and in the presence of the catalyst and oxygen to reduce the NO_x.

The use of a catalyst results in two advantages of the SCR process over SNCR, the higher NO_x reduction efficiency and the lower and broader temperature ranges. However, the decrease in reaction temperature and increase in efficiency is accompanied by a significant increase in capital and operating costs (EPA, 2002). The cost increase is due to the large amount of catalyst required.

The SCR system can utilize either aqueous or anhydrous ammonia as the reagent. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Today, catalyst formulations include single component, multi-component, or active phase with a support structure. Most catalyst formulations contain additional compounds or supports, providing thermal and structural stability or to increase surface area (EPA, 2002).

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include: reaction temperature range;

AT-A-GLANCE TABLE FOR POINT SOURCES

residence time available in the optimum temperature range; degree of mixing between the injected reagent and the combustion gases; uncontrolled NO_x concentration level; molar ratio of injected reagent to uncontrolled NO_x; ammonia slip; catalyst activity; catalyst selectivity; pressure drop across the catalyst; catalyst pitch; catalyst deactivation; and catalyst management (EPA, 2001).

References:

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Process Heaters," EPA-453/R-93-034, Research Triangle Park, NC, September 1993.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Process Heaters - LPG - Small Sources

Control Measure Name: Low NOx Burner

Rule Name: Not Applicable

Pechan Measure Code: N0481S, N04801

POD: 48

Application: This control is the use of low NOx burner (LNB) technology to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another.

This control is applicable to small (40 to 174 MMBtu/hr) LPG-fired process heaters with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

30600107 Process Heaters, LPG-fired

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 45% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by power output (Pechan, 1998).

Small source = 40 to 174 MMBtu/hr

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned along with a capital to annual costs ratio of 7.3. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 15 years (EPA, 1993).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 48% (Pechan, 2001).

Cost Effectiveness: The default cost effectiveness value used in AirControlNET is \$3,740 per ton NOx reduced from both uncontrolled and RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-

AT-A-GLANCE TABLE FOR POINT SOURCES

air LNBs create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNBs create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

References:

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Process Heaters," EPA,-453/R-93-034, Research Triangle Park, NC, September 1993.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Process Heaters - LPG - Small Sources

Control Measure Name: Low NOx Burner + Flue Gas Recirculation

Rule Name: Not Applicable

Pechan Measure Code: N0482S, N04802

POD: 48

Application: This control is the use of low NOx burner (LNB) technology and flue gas recirculation (FGR) to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another.

This control is applicable to small (40 to 174 MMBtu/hr) LPG-fired process heaters with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

30600107 Process Heaters, LPG-fired

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 48% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by power output (Pechan, 1998).

Small source = less than 1 ton NOx per ozone season day

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). The basis of the costs are model plant data in the Alternative Control Techniques (ACT) document (EPA, 1993). From this analysis, default cost per ton values are assigned along with a capital to annual costs ratio of 7.1. A discount rate of 10 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 15 years (EPA, 1993).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 48% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown is estimated using the detailed information in Table 6-4 and Ch. 6 of the Process Heaters ACT. The breakdown was obtained using the O&M costs for a mechanical draft process heater fired on distillate oil and having a capacity of 69 MMBTU per hour. The cost percentage is applied to heaters fired on LPG via technology transfer (Pechan, 1998). A capacity factor of 0.58 is used in estimating the O&M cost breakdown.

Electricity: \$0.06 per kw-hr

AT-A-GLANCE TABLE FOR POINT SOURCES

Cost Effectiveness: The default cost effectiveness values are \$4,250 per ton NO_x reduced from uncontrolled and \$19,540 per ton NO_x reduced from RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNBs create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNBs create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

References:

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Process Heaters," EPA-453/R-93-034, Research Triangle Park, NC, September 1993.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Process Heaters - LPG - Small Sources

Control Measure Name: Selective Non-Catalytic Reduction (SNCR)

Rule Name: Not Applicable

Pechan Measure Code: N0483S, N04803

POD: 48

Application: This control is the reduction of NO_x emission through selective non-catalytic reduction add-on controls. SNCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NO_x) into molecular nitrogen (N₂) and water vapor (H₂O).

This control applies to small (<1 ton NO_x emissions per OSD) LPG-fired process heaters (SCC 30600107) with uncontrolled NO_x emissions greater than 10 tons per year.

Affected SCC:

30600107 Process Heaters, LPG-fired

Pollutant(s)	PM10	PM2.5	EC	OC	NO _x	VOC	SO ₂	NH ₃	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 60% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NO_x emission levels (Pechan, 1998).

Small source = emission levels less than 1 ton per ozone season day

Costs for stationary source NO_x control are based on an analysis of EPA's NO_x State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned for small sources. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 15 years (EPA, 1993).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 48% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown is estimated using the detailed information in Table 6-4 and Ch. 6 of the Process Heaters ACT. The breakdown was obtained using the O&M costs for a mechanical draft process heater fired on distillate oil and having a capacity of 69 MMBTU per hour. The cost percentage is applied to heaters fired on LPG via technology transfer (Pechan, 1998). A capacity factor of 0.58 is used in estimating the O&M cost breakdown.

Electricity: \$0.06 per kw-hr

Fuel (distillate oil): \$5.54 per MMBTU

AT-A-GLANCE TABLE FOR POINT SOURCES

Ammonia: \$0.125 per lb

Cost Effectiveness: The cost effectiveness used in AirControlNET for both reductions from baseline and reductions from RACT is \$3,180 per ton NO_x reduced (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

SNCR is the reduction of NO_x in flue gas to N₂ and water vapor. This reduction is done with a nitrogen based reducing reagent, such as ammonia or urea. The reagent can react with a number of flue gas components. However, the NO_x reduction reaction is favored for a specific temperature range and in the presence of oxygen (EPA, 2002).

Both ammonia and urea are used as reagents. The cost of the reagent represents a large part of the annual costs of an SNCR system. Ammonia is generally less expensive than urea. However, the choice of reagent is also based on physical properties and operational considerations (EPA, 2002).

Ammonia can be utilized in either aqueous or anhydrous form. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Urea based systems have several advantages, including several safety aspects. Urea is a nontoxic, less volatile liquid that can be stored and handled more safely than ammonia. Urea solution droplets can penetrate farther into the flue gas when injected into the boiler, enhancing mixing (EPA, 2002). Because of these advantages, urea is more commonly used than ammonia in large boiler applications.

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include:

Reaction temperature range;
Residence time available in the optimum temperature range;
Degree of mixing between the injected reagent and the combustion gases
Uncontrolled NO_x concentration level;
Molar ratio of injected reagent to uncontrolled NO_x ; and
Ammonia slip.

References:

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Process Heaters," EPA-453/R-93-034, Research Triangle Park, NC, September 1993.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

AT-A-GLANCE TABLE FOR POINT SOURCES

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Process Heaters - LPG - Small Sources

Control Measure Name: Ultra Low NOx Burner

Rule Name: Not Applicable

Pechan Measure Code: N0484S, N04804

POD: 48

Application: This control is the use of ultra-low NOx burner (ULNB) add-on technologies to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another. SCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NOx) into molecular nitrogen (N₂) and water vapor (H₂O).

This control applies to small (40 to 174 MMBtu/hr) LPG-fired process heaters with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

30600107 Process Heaters, LPG-fired

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 74% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by power output (Pechan, 1998).

Small source = 40 to 174 MMBtu/hr

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned along with a capital to annual costs ratio of 7.3. A discount rate of 10 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 15 years (EPA, 1993).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 48% (Pechan, 2001).

Cost Effectiveness: The default cost effectiveness value is \$2,140 per ton NOx reduced from both uncontrolled and RACT baselines (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNBs create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNBs create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

References:

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Process Heaters," EPA-453/R-93-034, Research Triangle Park, NC, September 1993.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Process Heaters - LPG - Small Sources

Control Measure Name: Selective Catalytic Reduction (SCR)

Rule Name: Not Applicable

Pechan Measure Code: N0485S, N04805

POD: 48

Application: This control is the selective catalytic reduction of NOx through add-on controls. SCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NOx) into molecular nitrogen (N₂) and water vapor (H₂O). The SCR utilizes a catalyst to increase the NOx removal efficiency, which allows the process to occur at lower temperatures.

Applies to small (<1 ton NOx per OSD) LPG process heaters with NOx emissions greater than 10 tons per year.

Affected SCC:

30600107 Process Heaters, LPG-fired

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 75% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NOx emission levels (Pechan, 1998).

Small source = emission levels less than 1 ton per ozone season day

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 15 years (EPA, 1993).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 48% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown is estimated using the detailed information in Table 6-4 and Ch. 6 of the Process Heaters ACT. The breakdown was obtained using the O&M costs for a mechanical draft process heater fired on distillate oil and having a capacity of 69 MMBTU per hour. The cost percentage is applied to heaters fired on LPG via technology transfer (Pechan, 1998). A capacity factor of 0.58 is used in estimating the O&M cost breakdown.

Electricity: \$0.06 per kw-hr

Fuel (distillate oil): \$5.54 per MMBTU

Ammonia: \$0.125 per lb

AT-A-GLANCE TABLE FOR POINT SOURCES

Cost Effectiveness: The cost effectiveness value used in AirControlNET is \$9,230 per ton NO_x reduced from both uncontrolled and RACT baselines (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

Selective Catalytic Reduction (SCR) has been widely applied to stationary source, fossil fuel-fired, combustion units for emission control since the early 1970s. SCR is typically implemented on units requiring a higher level of NO_x control than achievable by SNCR or other combustion controls (EPA, 2002).

Like SNCR, SCR is based on the chemical reduction of the NO_x molecule. The primary difference between SNCR and SCR is that SCR uses a metal-based catalyst to increase the rate of reaction (EPA, 2002). A nitrogen based reducing reagent, such as ammonia or urea, is injected into the flue gas. The reagent reacts selectively with the flue gas NO_x within a specific temperature range and in the presence of the catalyst and oxygen to reduce the NO_x.

The use of a catalyst results in two advantages of the SCR process over SNCR, the higher NO_x reduction efficiency and the lower and broader temperature ranges. However, the decrease in reaction temperature and increase in efficiency is accompanied by a significant increase in capital and operating costs (EPA, 2002). The cost increase is due to the large amount of catalyst required.

The SCR system can utilize either aqueous or anhydrous ammonia as the reagent. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Today, catalyst formulations include single component, multi-component, or active phase with a support structure. Most catalyst formulations contain additional compounds or supports, providing thermal and structural stability or to increase surface area (EPA, 2002).

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include: reaction temperature range; residence time available in the optimum temperature range; degree of mixing between the injected reagent and the combustion gases; uncontrolled NO_x concentration level; molar ratio of injected reagent to uncontrolled NO_x; ammonia slip; catalyst activity; catalyst selectivity; pressure drop across the catalyst; catalyst pitch; catalyst deactivation; and catalyst management (EPA, 2001).

References:

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Process Heaters," EPA-453/R-93-034, Research Triangle Park, NC, September, 1993.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle

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Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Process Heaters - LPG - Small Sources

Control Measure Name: Low NOx Burner (LNB) + SNCR

Rule Name: Not Applicable

Pechan Measure Code: N0486S, N04806

POD: 48

Application: This control is the use of low NOx burner (LNB) technology and selective non-catalytic reduction (SNCR) to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another. SNCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NOx) into molecular nitrogen (N2) and water vapor (H2O).

This control is applicable to small (40 to 174 MMBtu/hr) LPG-fired process heaters with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

30600107 Process Heaters, LPG-fired

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 78% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by power output (Pechan, 1998).

Small source = 40 to 174 MMBtu/hr

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). The basis of the costs are model plant data in the Alternative Control Techniques (ACT) document (EPA, 1993). From this analysis, default cost per ton values are assigned along with a capital to annual costs ratio of 6.5. A discount rate of 10 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 15 years (EPA, 1993).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 48% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown is estimated using the detailed information in Table 6-4 and Ch. 6 of the Process Heaters ACT. The breakdown was obtained using the O&M costs for a mechanical draft process heater fired on distillate oil and having a capacity of 69 MMBTU per hour. The cost percentage is applied to heaters fired on LPG via technology transfer (Pechan, 1998). A capacity factor of 0.58 is used in estimating the O&M cost breakdown.

AT-A-GLANCE TABLE FOR POINT SOURCES

Electricity: \$0.06 per kw-hr
Fuel (distillate oil): \$5.54 per MMBTU
Ammonia: \$0.125 per lb

Cost Effectiveness: The default cost effectiveness values are \$3,620 per ton NO_x reduced from uncontrolled and \$3,830 per ton NO_x reduced from RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNB's create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNB's create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

SNCR is the reduction of NO_x in flue gas to N₂ and water vapor. This reduction is done with a nitrogen based reducing reagent, such as ammonia or urea. The reagent can react with a number of flue gas components. However, the NO_x reduction reaction is favored for a specific temperature range and in the presence of oxygen (EPA, 2002).

Both ammonia and urea are used as reagents. The cost of the reagent represents a large part of the annual costs of an SNCR system. Ammonia is generally less expensive than urea. However, the choice of reagent is also based on physical properties and operational considerations (EPA, 2002).

Ammonia can be utilized in either aqueous or anhydrous form. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Urea based systems have several advantages, including several safety aspects. Urea is a nontoxic, less volatile liquid that can be stored and handled more safely than ammonia. Urea solution droplets can penetrate farther into the flue gas when injected into the boiler, enhancing mixing (EPA, 2002). Because of these advantages, urea is more commonly used than ammonia in large boiler applications.

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include:

Reaction temperature range;
Residence time available in the optimum temperature range;
Degree of mixing between the injected reagent and the combustion gases
Uncontrolled NO_x concentration level;
Molar ratio of injected reagent to uncontrolled NO_x ; and
Ammonia slip.

References:

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Process Heaters," EPA-453/R-93-034, Research Triangle Park, NC, September 1993.

AT-A-GLANCE TABLE FOR POINT SOURCES

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Process Heaters - LPG - Small Sources

Control Measure Name: Low NOx Burner (LNB) + Selective Catalytic Reduction (SCR)

Rule Name: Not Applicable

Pechan Measure Code: N0487S, N04807

POD: 48

Application: This control is the use of low NOx burner (LNB) technology and selective catalytic reduction (SCR) to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another. SCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NOx) into molecular nitrogen (N₂) and water vapor (H₂O). The SCR utilizes a catalyst to increase the NOx removal efficiency, which allows the process to occur at lower temperatures.

This control is applicable to small (40 to 174 MMBtu/hr) LPG-fired process heaters with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

30600107 Process Heaters, LPG-fired

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 92% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by power output (Pechan, 1998).

Small source = 40 to 174 MMBtu/hr

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). The basis of the costs are model plant data in the Alternative Control Techniques (ACT) document (EPA, 1993). From this analysis, default cost per ton values are assigned along with a capital to annual costs ratio of 6.5. A discount rate of 10 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 15 years (EPA, 1993).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 48% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown is estimated using the detailed information in Table 6-4 and Ch. 6 of the Process Heaters ACT. The breakdown was obtained using the O&M costs for a mechanical draft process heater having a capacity of 69 MMBTU per hour, and distillate oil as fuel. The cost percentage is applied to heaters fired on LPG via technology transfer (Pechan, 1998). A capacity

AT-A-GLANCE TABLE FOR POINT SOURCES

factor of 0.58 is used in estimating the O&M cost breakdown.

Electricity: \$0.06 per kw-hr

Fuel (distillate oil): \$5.54 per MMBTU

Ammonia: \$0.125 per lb

Cost Effectiveness: The default cost effectiveness values are \$9,120 per ton NO_x reduced from uncontrolled and \$15,350 per ton NO_x reduced from RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNB's create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNB's create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

Selective Catalytic Reduction (SCR) has been widely applied to stationary source, fossil fuel-fired, combustion units for emission control since the early 1970s. SCR is typically implemented on units requiring a higher level of NO_x control than achievable by SNCR or other combustion controls (EPA, 2002).

Like SNCR, SCR is based on the chemical reduction of the NO_x molecule. The primary difference between SNCR and SCR is that SCR uses a metal-based catalyst to increase the rate of reaction (EPA, 2002). A nitrogen based reducing reagent, such as ammonia or urea, is injected into the flue gas. The reagent reacts selectively with the flue gas NO_x within a specific temperature range and in the presence of the catalyst and oxygen to reduce the NO_x.

The use of a catalyst results in two advantages of the SCR process over SNCR, the higher NO_x reduction efficiency and the lower and broader temperature ranges. However, the decrease in reaction temperature and increase in efficiency is accompanied by a significant increase in capital and operating costs (EPA, 2002). The cost increase is due to the large amount of catalyst required.

The SCR system can utilize either aqueous or anhydrous ammonia as the reagent. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Today, catalyst formulations include single component, multi-component, or active phase with a support structure. Most catalyst formulations contain additional compounds or supports, providing thermal and structural stability or to increase surface area (EPA, 2002).

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include: reaction temperature range; residence time available in the optimum temperature range; degree of mixing between the injected reagent and the combustion gases; uncontrolled NO_x concentration level; molar ratio of injected reagent to uncontrolled NO_x; ammonia slip; catalyst activity; catalyst selectivity; pressure drop across the catalyst; catalyst pitch; catalyst deactivation; and catalyst management (EPA, 2001).

AT-A-GLANCE TABLE FOR POINT SOURCES

References:

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Process Heaters," EPA,-453/R-93-034, Research Triangle Park, NC, September 1993.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Process Heaters - Natural Gas - Small Sources

Control Measure Name: Low NOx Burner

Rule Name: Not Applicable

Pechan Measure Code: N0271S, N02701

POD: 27

Application: This control is the use of low NOx burner (LNB) technology to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another.

This control is applicable to small (40 to 174 MMBtu/hr) natural gas-fired process heaters with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

30190003 Fuel Fired Equipment, Natural Gas: Process Heaters
30390003 Primary Metal Production, Fuel Fired Equipment, Natural Gas: Process Heaters
30490003 Fuel Fired Equipment, Natural Gas: Process Heaters
30590003 Fuel Fired Equipment, Natural Gas: Process Heaters
30600102 Process Heaters, Gas-fired **
30600104 Petroleum Industry, Process Heaters, Gas-fired
30600105 Process Heaters, Natural Gas-fired
30790003 Pulp, Paper & Wood Products, Fuel Fired Equipment, Natural Gas-Process Heaters
30890003 Fuel Fired Equipment, Natural Gas: Process Heaters
31000404 Oil and Gas Production, Process Heaters, Natural Gas
31000414 Process Heaters, Natural Gas: Steam Generators
39990003 Miscellaneous Manufacturing Industries, Natural Gas: Process Heaters

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 50% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by power output (Pechan, 1998).

Small source = 40 to 174 MMBtu/hr

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). The basis of the costs are model plant data for mechanical draft heaters firing natural gas and oil contained in the Alternative Control Techniques (ACT) document (EPA, 1993). From this analysis, default cost per ton values are assigned along with a capital to annual costs ratio of 7.3. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 15 years (EPA, 1993).

In general, the incremental default cost is used for sources where there are existing

AT-A-GLANCE TABLE FOR POINT SOURCES

controls (RACT baseline), with efficiencies less than or equal to 55% (Pechan, 2001).

O&M Cost Components: The maintenance cost is estimated as a flat percentage (2.75%) of the total capital costs (see pages 6-4 and 6-5 of the ACT document).

Impacts on operational costs are considered minimal, according to the ACT document; therefore, O&M costs are a function of the maintenance cost only.

Cost Effectiveness: The default cost effectiveness value used in AirControlNET is \$2,200 per ton NO_x reduced from both uncontrolled and RACT (1990\$).

Comments:

Status: Demonstrated	Last Reviewed: 2001
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Additional Information:

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNBs create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNBs create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

References:

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Process Heaters," EPA-453/R-93-034, Research Triangle Park, NC, September 1993.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Process Heaters - Natural Gas - Small Sources

Control Measure Name: Low NOx Burner + Flue Gas Recirculation

Rule Name: Not Applicable

Pechan Measure Code: N0272S, N02702

POD: 27

Application: This control is the use of low NOx burner (LNB) technology and flue gas recirculation (FGR) to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another.

This control is applicable to small (40 to 174 MMBtu/hr) natural gas-fired process heaters with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

30190003 Fuel Fired Equipment, Natural Gas: Process Heaters
30390003 Primary Metal Production, Fuel Fired Equipment, Natural Gas: Process Heaters
30490003 Fuel Fired Equipment, Natural Gas: Process Heaters
30590003 Fuel Fired Equipment, Natural Gas: Process Heaters
30600102 Process Heaters, Gas-fired **
30600104 Petroleum Industry, Process Heaters, Gas-fired
30600105 Process Heaters, Natural Gas-fired
30790003 Pulp, Paper & Wood Products, Fuel Fired Equipment, Natural Gas-Process Heaters
30890003 Fuel Fired Equipment, Natural Gas: Process Heaters
31000404 Oil and Gas Production, Process Heaters, Natural Gas
31000414 Process Heaters, Natural Gas: Steam Generators
39990003 Miscellaneous Manufacturing Industries, Natural Gas: Process Heaters

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√/*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 55% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by power output (Pechan, 1998).

Small source = 40 to 174 MMBtu/hr

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). The basis of the costs are model plant data in the Alternative Control Techniques (ACT) document (EPA, 1993). From this analysis, default cost per ton values are assigned along with a capital to annual costs ratio of 6.9. A discount rate of 10 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 15 years (EPA, 1993).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 55% (Pechan, 2001).

AT-A-GLANCE TABLE FOR POINT SOURCES

O&M Cost Components: The O&M cost breakdown is estimated using the detailed information in Table 6-3 and Ch. 6 of the Process Heaters ACT. The breakdown was obtained using the O&M costs for a mechanical draft process heater having a capacity of 77 MMBTU per hour. A capacity factor of 0.5 is used in estimating the O&M cost breakdown.

Electricity: \$0.06 per kw-hr

Cost Effectiveness: The default cost effectiveness values are \$3,190 per ton NO_x reduced from uncontrolled and \$15,580 per ton NO_x reduced from RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNBs create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNBs create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

References:

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Process Heaters," EPA-453/R-93-034, Research Triangle Park, NC, September 1993.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Process Heaters - Natural Gas - Small Sources

Control Measure Name: Selective Non-Catalytic Reduction (SNCR)

Rule Name: Not Applicable

Pechan Measure Code: N0273S, N02703

POD: 27

Application: This control is the reduction of NO_x emission through selective non-catalytic reduction add-on controls. SNCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NO_x) into molecular nitrogen (N₂) and water vapor (H₂O).

This control applies to small (<1 ton NO_x emissions per OSD) natural gas-fired process heaters with uncontrolled NO_x emissions greater than 10 tons per year.

Affected SCC:

30190003 Fuel Fired Equipment, Natural Gas: Process Heaters
30390003 Primary Metal Production, Fuel Fired Equipment, Natural Gas: Process Heaters
30490003 Fuel Fired Equipment, Natural Gas: Process Heaters
30590003 Fuel Fired Equipment, Natural Gas: Process Heaters
30600102 Process Heaters, Gas-fired **
30600104 Petroleum Industry, Process Heaters, Gas-fired
30600105 Process Heaters, Natural Gas-fired
30790003 Pulp, Paper & Wood Products, Fuel Fired Equipment, Natural Gas-Process Heaters
30890003 Fuel Fired Equipment, Natural Gas: Process Heaters
31000404 Oil and Gas Production, Process Heaters, Natural Gas
31000414 Process Heaters, Natural Gas: Steam Generators
39990003 Miscellaneous Manufacturing Industries, Natural Gas: Process Heaters

Pollutant(s)	PM10	PM2.5	EC	OC	NO _x	VOC	SO ₂	NH ₃	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 60% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NO_x emission levels (Pechan, 1998).

Small source = emission levels less than 1 ton per ozone season day

Costs for stationary source NO_x control are based on an analysis of EPA's NO_x State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned for small sources. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 15 years (EPA, 1993).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 55% (Pechan, 2001).

AT-A-GLANCE TABLE FOR POINT SOURCES

O&M Cost Components: The O&M cost breakdown is estimated using the detailed information in Table 6-3 and Ch. 6 of the Process Heaters ACT. The breakdown was obtained using the O&M costs for a mechanical draft process heater having a capacity of 77 MMBTU per hour. A capacity factor of 0.5 is used in estimating the O&M cost breakdown.

Electricity: \$0.06 per kw-hr

Fuel (natural gas): \$2.00 per MMBTU

Ammonia: \$0.125 per lb

Cost Effectiveness: The cost effectiveness used in AirControlNET for both reductions from baseline and reductions from RACT is \$2,850 per ton NO_x reduced (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

SNCR is the reduction of NO_x in flue gas to N₂ and water vapor. This reduction is done with a nitrogen based reducing reagent, such as ammonia or urea. The reagent can react with a number of flue gas components. However, the NO_x reduction reaction is favored for a specific temperature range and in the presence of oxygen (EPA, 2002).

Both ammonia and urea are used as reagents. The cost of the reagent represents a large part of the annual costs of an SNCR system. Ammonia is generally less expensive than urea. However, the choice of reagent is also based on physical properties and operational considerations (EPA, 2002).

Ammonia can be utilized in either aqueous or anhydrous form. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Urea based systems have several advantages, including several safety aspects. Urea is a nontoxic, less volatile liquid that can be stored and handled more safely than ammonia. Urea solution droplets can penetrate farther into the flue gas when injected into the boiler, enhancing mixing (EPA, 2002). Because of these advantages, urea is more commonly used than ammonia in large boiler applications.

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include:

Reaction temperature range;

Residence time available in the optimum temperature range;

Degree of mixing between the injected reagent and the combustion gases

Uncontrolled NO_x concentration level;

Molar ratio of injected reagent to uncontrolled NO_x ; and ammonia slip.

References:

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Process Heaters," EPA-453/R-93-034, Research Triangle Park, NC, September 1993.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards,

AT-A-GLANCE TABLE FOR POINT SOURCES

"EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Process Heaters - Natural Gas - Small Sources

Control Measure Name: Ultra Low NOx Burner

Rule Name: Not Applicable

Pechan Measure Code: N0274S, N02704

POD: 27

Application: This control is the use of ultra-low NOx burner (ULNB) add-on technologies to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another. SCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NOx) into molecular nitrogen (N₂) and water vapor (H₂O).

This control applies to small (40 to 174 MMBtu/hr) natural gas-fired process heaters with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

30190003 Fuel Fired Equipment, Natural Gas: Process Heaters
30390003 Primary Metal Production, Fuel Fired Equipment, Natural Gas: Process Heaters
30490003 Fuel Fired Equipment, Natural Gas: Process Heaters
30590003 Fuel Fired Equipment, Natural Gas: Process Heaters
30600102 Process Heaters, Gas-fired **
30600104 Petroleum Industry, Process Heaters, Gas-fired
30600105 Process Heaters, Natural Gas-fired
30790003 Pulp, Paper & Wood Products, Fuel Fired Equipment, Natural Gas-Process Heaters
30890003 Fuel Fired Equipment, Natural Gas: Process Heaters
31000404 Oil and Gas Production, Process Heaters, Natural Gas
31000414 Process Heaters, Natural Gas: Steam Generators
39990003 Miscellaneous Manufacturing Industries, Natural Gas: Process Heaters

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√/*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 75% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by power output (Pechan, 1998).

Small source = 40 to 174 MMBtu/hr

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned along with a capital to annual costs ratio of 7.3. A discount rate of 10 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 15 years (EPA, 1993).

In general, the incremental default cost is used for sources where there are existing

AT-A-GLANCE TABLE FOR POINT SOURCES

controls (RACT baseline), with efficiencies less than or equal to 55% (Pechan, 2001).

Cost Effectiveness: The default cost effectiveness value is \$1,500 per ton NO_x reduced from both uncontrolled and RACT baselines (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNBs create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNBs create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

References:

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Process Heaters," EPA-453/R-93-034, Research Triangle Park, NC, September 1993.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Process Heaters - Natural Gas - Small Sources

Control Measure Name: Selective Catalytic Reduction (SCR)

Rule Name: Not Applicable

Pechan Measure Code: N0275S, N02705

POD: 27

Application: This control is the selective catalytic reduction of NO_x through add-on controls. SCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NO_x) into molecular nitrogen (N₂) and water vapor (H₂O). The SCR utilizes a catalyst to increase the NO_x removal efficiency, which allows the process to occur at lower temperatures.

Applies to small (<1 ton NO_x per OSD) natural gas fired process heaters with NO_x emissions greater than 10 tons per year.

Affected SCC:

30190003 Fuel Fired Equipment, Natural Gas: Process Heaters
30390003 Primary Metal Production, Fuel Fired Equipment, Natural Gas: Process Heaters
30490003 Fuel Fired Equipment, Natural Gas: Process Heaters
30590003 Fuel Fired Equipment, Natural Gas: Process Heaters
30600102 Process Heaters, Gas-fired **
30600104 Petroleum Industry, Process Heaters, Gas-fired
30600105 Process Heaters, Natural Gas-fired
30790003 Pulp, Paper & Wood Products, Fuel Fired Equipment, Natural Gas-Process Heaters
30890003 Fuel Fired Equipment, Natural Gas: Process Heaters
31000404 Oil and Gas Production, Process Heaters, Natural Gas
31000414 Process Heaters, Natural Gas: Steam Generators
39990003 Miscellaneous Manufacturing Industries, Natural Gas: Process Heaters

Pollutant(s)	PM10	PM2.5	EC	OC	NO _x	VOC	SO ₂	NH ₃	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 75% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NO_x emission levels (Pechan, 1998).

Small source = emission levels less than 1 ton per ozone season day

Costs for stationary source NO_x control are based on an analysis of EPA's NO_x State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 15 years (EPA, 1993).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 55% (Pechan, 2001).

AT-A-GLANCE TABLE FOR POINT SOURCES

O&M Cost Components: The O&M cost breakdown is estimated using the detailed information in Table 6-3 and Ch. 6 of the Process Heaters ACT. The breakdown was obtained using the O&M costs for a mechanical draft process heater having a capacity of 77 MMBTU per hour. A capacity factor of 0.5 is used in estimating the O&M cost breakdown.

Electricity: \$0.06 per kw-hr

Fuel (natural gas): \$2.00 per MMBTU

Ammonia: \$0.125 per lb

Cost Effectiveness: The cost effectiveness value used in AirControlNET is \$12,040 per ton NO_x reduced from both uncontrolled and RACT baselines (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

Selective Catalytic Reduction (SCR) has been widely applied to stationary source, fossil fuel-fired, combustion units for emission control since the early 1970s. SCR is typically implemented on units requiring a higher level of NO_x control than achievable by SNCR or other combustion controls (EPA, 2002).

Like SNCR, SCR is based on the chemical reduction of the NO_x molecule. The primary difference between SNCR and SCR is that SCR uses a metal-based catalyst to increase the rate of reaction (EPA, 2002). A nitrogen based reducing reagent, such as ammonia or urea, is injected into the flue gas. The reagent reacts selectively with the flue gas NO_x within a specific temperature range and in the presence of the catalyst and oxygen to reduce the NO_x.

The use of a catalyst results in two advantages of the SCR process over SNCR, the higher NO_x reduction efficiency and the lower and broader temperature ranges. However, the decrease in reaction temperature and increase in efficiency is accompanied by a significant increase in capital and operating costs (EPA, 2002). The cost increase is due to the large amount of catalyst required.

The SCR system can utilize either aqueous or anhydrous ammonia as the reagent. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Today, catalyst formulations include single component, multi-component, or active phase with a support structure. Most catalyst formulations contain additional compounds or supports, providing thermal and structural stability or to increase surface area (EPA, 2002).

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include: reaction temperature range; residence time available in the optimum temperature range; degree of mixing between the injected reagent and the combustion gases; uncontrolled NO_x concentration level; molar ratio of injected reagent to uncontrolled NO_x; ammonia slip; catalyst activity; catalyst selectivity; pressure drop across the catalyst; catalyst pitch; catalyst deactivation; and catalyst management (EPA, 2001).

AT-A-GLANCE TABLE FOR POINT SOURCES

References:

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Process Heaters," EPA,-453/R-93-034, Research Triangle Park, NC, September 1993.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Process Heaters - Natural Gas - Small Sources

Control Measure Name: Low NOx Burner (LNB) + SNCR

Rule Name: Not Applicable

Pechan Measure Code: N0276S, N02706

POD: 27

Application: This control is the use of low NOx burner (LNB) technology and selective non-catalytic reduction (SNCR) to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another. SNCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NOx) into molecular nitrogen (N2) and water vapor (H2O).

This control is applicable to small (40 to 174 MMBtu/hr) natural gas-fired process heaters with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

30190003 Fuel Fired Equipment, Natural Gas: Process Heaters
30390003 Primary Metal Production, Fuel Fired Equipment, Natural Gas: Process Heaters
30490003 Fuel Fired Equipment, Natural Gas: Process Heaters
30590003 Fuel Fired Equipment, Natural Gas: Process Heaters
30600102 Process Heaters, Gas-fired **
30600104 Petroleum Industry, Process Heaters, Gas-fired
30600105 Process Heaters, Natural Gas-fired
30790003 Pulp, Paper & Wood Products, Fuel Fired Equipment, Natural Gas-Process Heaters
30890003 Fuel Fired Equipment, Natural Gas: Process Heaters
31000404 Oil and Gas Production, Process Heaters, Natural Gas
31000414 Process Heaters, Natural Gas: Steam Generators
39990003 Miscellaneous Manufacturing Industries, Natural Gas: Process Heaters

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√/*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 80% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by power output (Pechan, 1998).

Small source = 40 to 174 MMBtu/hr

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). The basis of the costs are model plant data in the Alternative Control Techniques (ACT) document (EPA, 1993). From this analysis, default cost per ton values are assigned along with a capital to annual costs ratio of 6.7. A discount rate of 10 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 15 years (EPA, 1993).

AT-A-GLANCE TABLE FOR POINT SOURCES

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 55% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown is estimated using the detailed information in Table 6-3 and Ch. 6 of the Process Heaters ACT. The breakdown was obtained using the O&M costs for a mechanical draft process heater having a capacity of 77 MMBTU per hour. A capacity factor of 0.5 is used in estimating the O&M cost breakdown.

Electricity: \$0.06 per kw-hr

Fuel (natural gas): \$2.00 per MMBTU

Ammonia: \$0.125 per lb

Cost Effectiveness: The default cost effectiveness values are \$3,520 per ton NO_x reduced from uncontrolled and \$6,600 per ton NO_x reduced from RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNB's create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNB's create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

SNCR is the reduction of NO_x in flue gas to N₂ and water vapor. This reduction is done with a nitrogen based reducing reagent, such as ammonia or urea. The reagent can react with a number of flue gas components. However, the NO_x reduction reaction is favored for a specific temperature range and in the presence of oxygen (EPA, 2002).

Both ammonia and urea are used as reagents. The cost of the reagent represents a large part of the annual costs of an SNCR system. Ammonia is generally less expensive than urea. However, the choice of reagent is also based on physical properties and operational considerations (EPA, 2002).

Ammonia can be utilized in either aqueous or anhydrous form. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Urea based systems have several advantages, including several safety aspects. Urea is a nontoxic, less volatile liquid that can be stored and handled more safely than ammonia. Urea solution droplets can penetrate farther into the flue gas when injected into the boiler, enhancing mixing (EPA, 2002). Because of these advantages, urea is more commonly used than ammonia in large boiler applications.

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include:

Reaction temperature range;

Residence time available in the optimum temperature range;

AT-A-GLANCE TABLE FOR POINT SOURCES

Degree of mixing between the injected reagent and the combustion gases
Uncontrolled NO_x concentration level;
Molar ratio of injected reagent to uncontrolled NO_x ; and ammonia slip.

References:

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Process Heaters," EPA,-453/R-93-034, Research Triangle Park, NC, September 1993.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Process Heaters - Natural Gas - Small Sources

Control Measure Name: Low NOx Burner (LNB) + Selective Catalytic Reduction (SCR)

Rule Name: Not Applicable

Pechan Measure Code: N0277S, N02707

POD: 27

Application: This control is the use of low NOx burner (LNB) technology and selective catalytic reduction (SCR) to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another. SCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NOx) into molecular nitrogen (N₂) and water vapor (H₂O). The SCR utilizes a catalyst to increase the NOx removal efficiency, which allows the process to occur at lower temperatures.

This control is applicable to small (40 to 174 MMBtu/hr) natural gas-fired process heaters with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

30190003 Fuel Fired Equipment, Natural Gas: Process Heaters
30390003 Primary Metal Production, Fuel Fired Equipment, Natural Gas: Process Heaters
30490003 Fuel Fired Equipment, Natural Gas: Process Heaters
30590003 Fuel Fired Equipment, Natural Gas: Process Heaters
30600102 Process Heaters, Gas-fired **
30600104 Petroleum Industry, Process Heaters, Gas-fired
30600105 Process Heaters, Natural Gas-fired
30790003 Pulp, Paper & Wood Products, Fuel Fired Equipment, Natural Gas-Process Heaters
30890003 Fuel Fired Equipment, Natural Gas: Process Heaters
31000404 Oil and Gas Production, Process Heaters, Natural Gas
31000414 Process Heaters, Natural Gas: Steam Generators
39990003 Miscellaneous Manufacturing Industries, Natural Gas: Process Heaters

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 88% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by power output (Pechan, 1998).

Small source = 40 to 174 MMBtu/hr

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). The basis of the costs are model plant data in the Alternative Control Techniques (ACT) document (EPA, 1993). From this analysis, default cost per ton values are assigned along with a capital to annual costs ratio of 6.8. A discount rate of 10 percent and a capacity factor of 65 percent

AT-A-GLANCE TABLE FOR POINT SOURCES

are assumed, along with an equipment life of 15 years (EPA, 1993).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 55% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown is estimated using the detailed information in Table 6-3 and Ch. 6 of the ACT for Process Heaters. The breakdown was obtained using the O&M costs for a mechanical draft process heater having a capacity of 77 MMBTU per hour. A capacity factor of 0.5 is used in estimating the O&M cost breakdown.

Electricity: \$0.06 per kw-hr

Fuel (natural gas): \$2.00 per MMBTU

Ammonia: \$0.125 per lb

Cost Effectiveness: The default cost effectiveness values are \$11,560 per ton NO_x reduced from uncontrolled and \$27,910 per ton NO_x reduced from RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNB's create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNB's create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

Selective Catalytic Reduction (SCR) has been widely applied to stationary source, fossil fuel-fired, combustion units for emission control since the early 1970s. SCR is typically implemented on units requiring a higher level of NO_x control than achievable by SNCR or other combustion controls (EPA, 2002).

Like SNCR, SCR is based on the chemical reduction of the NO_x molecule. The primary difference between SNCR and SCR is that SCR uses a metal-based catalyst to increase the rate of reaction (EPA, 2002). A nitrogen based reducing reagent, such as ammonia or urea, is injected into the flue gas. The reagent reacts selectively with the flue gas NO_x within a specific temperature range and in the presence of the catalyst and oxygen to reduce the NO_x.

The use of a catalyst results in two advantages of the SCR process over SNCR, the higher NO_x reduction efficiency and the lower and broader temperature ranges. However, the decrease in reaction temperature and increase in efficiency is accompanied by a significant increase in capital and operating costs (EPA, 2002). The cost increase is due to the large amount of catalyst required.

The SCR system can utilize either aqueous or anhydrous ammonia as the reagent. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Today, catalyst formulations include single component, multi-component, or active phase with a

AT-A-GLANCE TABLE FOR POINT SOURCES

support structure. Most catalyst formulations contain additional compounds or sup-ports, providing thermal and structural stability or to increase surface area (EPA, 2002).

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include: reaction temperature range; residence time available in the optimum temperature range; degree of mixing between the injected reagent and the combustion gases; uncontrolled NO_x concentration level; molar ratio of injected reagent to uncontrolled NO_x; ammonia slip; catalyst activity; catalyst selectivity; pressure drop across the catalyst; catalyst pitch; catalyst deactivation; and catalyst management (EPA, 2001).

References:

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Process Heaters," EPA-453/R-93-034, Research Triangle Park, NC, September 1993.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Process Heaters - Other Fuel - Small Sources

Control Measure Name: Low NOx Burner + Flue Gas Recirculation

Rule Name: Not Applicable

Pechan Measure Code: N0491S, N04901

POD: 49

Application: This control is the use of low NOx burner (LNB) technology and flue gas recirculation (FGR) to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another.

This control is applicable to small (40 to 174 MMBtu/hr) other (miscellaneous) fuel-fired process heaters with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

30600199 Process Heaters, Other Not Classified

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 34% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by power output (Pechan, 1998).

Small source = 40 to 174 MMBtu/hr

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). The basis of the costs are model plant data in the Alternative Control Techniques (ACT) document (EPA, 1993). From this analysis, default cost per ton values are assigned along with a capital to annual costs ratio of 7.1. A discount rate of 10 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 15 years (EPA, 1993).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies greater than 26% and less than or equal to 55% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown is estimated using the detailed information in Table 6-4 and Ch. 6 of the Process Heaters ACT. The breakdown was obtained using the O&M costs for a mechanical draft process heater fired on residual fuel oil and having a capacity of 69 MMBTU per hour. The cost percentage is applied to heaters fired on other fuel via technology transfer (Pechan, 1998). A capacity factor of 0.58 is used in estimating the O&M cost breakdown.

Electricity: \$0.06 per kw-hr

AT-A-GLANCE TABLE FOR POINT SOURCES

Cost Effectiveness: The default cost effectiveness value is \$3,490 per ton NO_x reduced from both uncontrolled and RACT baselines (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNBs create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNBs create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

References:

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Process Heaters," EPA-453/R-93-034, Research Triangle Park, NC, September 1993.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Process Heaters - Other Fuel - Small Sources

Control Measure Name: Low NOx Burner

Rule Name: Not Applicable

Pechan Measure Code: N0492S, N04902

POD: 49

Application: This control is the use of low NOx burner (LNB) technology to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another.

This control is applicable to small (40 to 174 MMBtu/hr) un-classified fuel process heaters (SCC 30600199) with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

30600199 Process Heaters, Other Not Classified

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 37% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by power output (Pechan, 1998).

Small source = 40 to 174 MMBtu/hr

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). The basis of the costs are model plant data for mechanical draft heaters firing natural gas and oil contained in the Alternative Control Techniques (ACT) document (EPA, 1993). From this analysis, default cost per ton values are assigned along with a capital to annual costs ratio of 7.3. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 15 years (EPA, 1993).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies greater than 26% and less than or equal to 55% (Pechan, 2001).

Cost Effectiveness: The default cost effectiveness value used in AirControlNET is \$2,520 per ton NOx reduced from both uncontrolled and RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNBs create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNBs create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

References:

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Process Heaters," EPA-453/R-93-034, Research Triangle Park, NC, September 1993.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Process Heaters - Other Fuel - Small Sources

Control Measure Name: Selective Non-Catalytic Reduction (SNCR)

Rule Name: Not Applicable

Pechan Measure Code: N0493S, N04903

POD: 49

Application: This control is the reduction of NO_x emission through selective non-catalytic reduction add-on controls. SNCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NO_x) into molecular nitrogen (N₂) and water vapor (H₂O).

This control applies to small (<1 ton NO_x emissions per OSD) process heaters (fired with fuels classified as other) with uncontrolled NO_x emissions greater than 10 tons per year. These sources are classified under SCC 30600199.

Affected SCC:

30600199 Process Heaters, Other Not Classified

Pollutant(s)	PM10	PM2.5	EC	OC	NO _x	VOC	SO ₂	NH ₃	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 60% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NO_x emission levels (Pechan, 1998).

Small source = emission levels less than 1 ton per ozone season day

Costs for stationary source NO_x control are based on an analysis of EPA's NO_x State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned for small sources. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 15 years (EPA, 1993).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies greater than 26% and less than or equal to 55% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown is estimated using the detailed information in Table 6-4 and Ch. 6 of the Process Heaters ACT. The breakdown was obtained using the O&M costs for a mechanical draft process heater fired on residual fuel oil and having a capacity of 69 MMBTU per hour. The cost percentage is applied to heaters fired on other fuel via technology transfer (Pechan, 1998). A capacity factor of 0.58 is used in estimating the O&M cost breakdown.

Electricity: \$0.06 per kw-hr

AT-A-GLANCE TABLE FOR POINT SOURCES

Fuel (residual oil): \$3.00 per MMBTU
Ammonia: \$0.125 per lb

Cost Effectiveness: The cost effectiveness used in AirControlNET for both reductions from baseline and reductions from RACT is \$1,930 per ton NO_x reduced (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

SNCR is the reduction of NO_x in flue gas to N₂ and water vapor. This reduction is done with a nitrogen based reducing reagent, such as ammonia or urea. The reagent can react with a number of flue gas components. However, the NO_x reduction reaction is favored for a specific temperature range and in the presence of oxygen (EPA, 2002).

Both ammonia and urea are used as reagents. The cost of the reagent represents a large part of the annual costs of an SNCR system. Ammonia is generally less expensive than urea. However, the choice of reagent is also based on physical properties and operational considerations (EPA, 2002).

Ammonia can be utilized in either aqueous or anhydrous form. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Urea based systems have several advantages, including several safety aspects. Urea is a nontoxic, less volatile liquid that can be stored and handled more safely than ammonia. Urea solution droplets can penetrate farther into the flue gas when injected into the boiler, enhancing mixing (EPA, 2002). Because of these advantages, urea is more commonly used than ammonia in large boiler applications.

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include:

Reaction temperature range;
Residence time available in the optimum temperature range;
Degree of mixing between the injected reagent and the combustion gases
Uncontrolled NO_x concentration level;
Molar ratio of injected reagent to uncontrolled NO_x ; and
Ammonia slip.

References:

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Process Heaters," EPA-453/R-93-034, Research Triangle Park, NC, September 1993.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle

AT-A-GLANCE TABLE FOR POINT SOURCES

Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Process Heaters - Other Fuel - Small Sources

Control Measure Name: Ultra Low NOx Burner

Rule Name: Not Applicable

Pechan Measure Code: N0494S, N04904

POD: 49

Application: This control is the use of ultra-low NOx burner (ULNB) add-on technologies to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another. SCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NOx) into molecular nitrogen (N₂) and water vapor (H₂O).

This control applies to small (40 to 174 MMBtu/hr) other (miscellaneous) fuel-fired process heaters with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

30600199 Process Heaters, Other Not Classified

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 73% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by power output (Pechan, 1998).

Small source = 40 to 174 MMBtu/hr

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned along with a capital to annual costs ratio of 7.3. A discount rate of 10 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 15 years (EPA, 1993).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies greater than 26% and less than or equal to 55% (Pechan, 2001).

Cost Effectiveness: The default cost effectiveness value is \$1,290 per ton NOx reduced from both uncontrolled and RACT baselines (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNBs create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNBs create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

References:

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Process Heaters," EPA-453/R-93-034, Research Triangle Park, NC, September 1993.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Process Heaters - Other Fuel - Small Sources

Control Measure Name: Low NOx Burner (LNB) + SNCR

Rule Name: Not Applicable

Pechan Measure Code: N0495S, N04905

POD: 49

Application: This control is the use of low NOx burner (LNB) technology and selective non-catalytic reduction (SNCR) to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another. SNCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NOx) into molecular nitrogen (N2) and water vapor (H2O).

This control is applicable to small (40 to 174 MMBtu/hr) other (not classified) fuel-fired process heaters with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

30600199 Process Heaters, Other Not Classified

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 75% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by power output (Pechan, 1998).

Small source = 40 to 174 MMBtu/hr

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). The basis of the costs are model plant data in the Alternative Control Techniques (ACT) document (EPA, 1993). From this analysis, default cost per ton values are assigned along with a capital to annual costs ratio of 6.4. A discount rate of 10 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 15 years (EPA, 1993).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies greater than 26% and less than or equal to 55% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown is estimated using the detailed information in Table 6-4 and Ch. 6 of the Process Heaters ACT. The breakdown was obtained using the O&M costs for a mechanical draft process heater fired on residual fuel oil and having a capacity of 69 MMBTU per hour. The cost percentage is applied to heaters fired on other fuel via technology transfer (Pechan, 1998). A capacity factor of 0.58 is used in estimating the O&M cost breakdown.

AT-A-GLANCE TABLE FOR POINT SOURCES

Electricity: \$0.06 per kw-hr
Fuel (residual oil): \$3.00 per MMBTU
Ammonia: \$0.125 per lb

Cost Effectiveness: The default cost effectiveness values are \$2,320 per ton NOx reduced from uncontrolled and \$2,080 per ton NOx reduced from RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNB's create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNB's create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

SNCR is the reduction of NOx in flue gas to N₂ and water vapor. This reduction is done with a nitrogen based reducing reagent, such as ammonia or urea. The reagent can react with a number of flue gas components. However, the NOx reduction reaction is favored for a specific temperature range and in the presence of oxygen (EPA, 2002).

Both ammonia and urea are used as reagents. The cost of the reagent represents a large part of the annual costs of an SNCR system. Ammonia is generally less expensive than urea. However, the choice of reagent is also based on physical properties and operational considerations (EPA, 2002).

Ammonia can be utilized in either aqueous or anhydrous form. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Urea based systems have several advantages, including several safety aspects. Urea is a nontoxic, less volatile liquid that can be stored and handled more safely than ammonia. Urea solution droplets can penetrate farther into the flue gas when injected into the boiler, enhancing mixing (EPA, 2002). Because of these advantages, urea is more commonly used than ammonia in large boiler applications.

The rate of reaction determines the amount of NOx removed from the flue gas. The important design and operational factors that affect the rate of reduction include:

Reaction temperature range;
Residence time available in the optimum temperature range;
Degree of mixing between the injected reagent and the combustion gases
Uncontrolled NOx concentration level;
Molar ratio of injected reagent to uncontrolled NOx ; and
Ammonia slip.

AT-A-GLANCE TABLE FOR POINT SOURCES

References:

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Process Heaters," EPA,-453/R-93-034, Research Triangle Park, NC, September 1993.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Process Heaters - Other Fuel - Small Sources

Control Measure Name: Selective Catalytic Reduction (SCR)

Rule Name: Not Applicable

Pechan Measure Code: N0496S, N04906

POD: 49

Application: This control is the selective catalytic reduction of NOx through add-on controls. SCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NOx) into molecular nitrogen (N2) and water vapor (H2O). The SCR utilizes a catalyst to increase the NOx removal efficiency, which allows the process to occur at lower temperatures.

Applies to small (<1 ton NOx per OSD) process heaters (SCC 30600199) with NOx emissions greater than 10 tons per year.

Affected SCC:

30600199 Process Heaters, Other Not Classified

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 75% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NOx emission levels (Pechan, 1998).

Small source = emission levels less than 1 ton per ozone season day

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 15 years (EPA, 1993).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies greater than 26% and less than or equal to 55% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown is estimated using the detailed information in Table 6-4 and Ch. 6 of the Process Heaters ACT. The breakdown was obtained using the O&M costs for a mechanical draft process heater fired on residual fuel oil and having a capacity of 69 MMBTU per hour. The cost percentage is applied to heaters fired on other fuel via technology transfer (Pechan, 1998). A capacity factor of 0.58 is used in estimating the O&M cost breakdown.

Electricity: \$0.06 per kw-hr

Fuel (residual oil): \$3.00 per MMBTU

AT-A-GLANCE TABLE FOR POINT SOURCES

Ammonia: \$0.125 per lb

Cost Effectiveness: The cost effectiveness value used in AirControlNET is \$5,350 per ton NO_x reduced from both uncontrolled and RACT baselines (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

Selective Catalytic Reduction (SCR) has been widely applied to stationary source, fossil fuel-fired, combustion units for emission control since the early 1970s. SCR is typically implemented on units requiring a higher level of NO_x control than achievable by SNCR or other combustion controls (EPA, 2002).

Like SNCR, SCR is based on the chemical reduction of the NO_x molecule. The primary difference between SNCR and SCR is that SCR uses a metal-based catalyst to increase the rate of reaction (EPA, 2002). A nitrogen based reducing reagent, such as ammonia or urea, is injected into the flue gas. The reagent reacts selectively with the flue gas NO_x within a specific temperature range and in the presence of the catalyst and oxygen to reduce the NO_x.

The use of a catalyst results in two advantages of the SCR process over SNCR, the higher NO_x reduction efficiency and the lower and broader temperature ranges. However, the decrease in reaction temperature and increase in efficiency is accompanied by a significant increase in capital and operating costs (EPA, 2002). The cost increase is due to the large amount of catalyst required.

The SCR system can utilize either aqueous or anhydrous ammonia as the reagent. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Today, catalyst formulations include single component, multi-component, or active phase with a support structure. Most catalyst formulations contain additional compounds or supports, providing thermal and structural stability or to increase surface area (EPA, 2002).

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include: reaction temperature range; residence time available in the optimum temperature range; degree of mixing between the injected reagent and the combustion gases; uncontrolled NO_x concentration level; molar ratio of injected reagent to uncontrolled NO_x; ammonia slip; catalyst activity; catalyst selectivity; pressure drop across the catalyst; catalyst pitch; catalyst deactivation; and catalyst management (EPA, 2001).

References:

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Process Heaters," EPA,-453/R-93-034, Research Triangle Park, NC, September 1993.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity

AT-A-GLANCE TABLE FOR POINT SOURCES

Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Process Heaters - Other Fuel - Small Sources

Control Measure Name: Low NOx Burner (LNB) + Selective Catalytic Reduction (SCR)

Rule Name: Not Applicable

Pechan Measure Code: N0497S, N04907

POD: 49

Application: This control is the use of low NOx burner (LNB) technology and selective catalytic reduction (SCR) to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another. SCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NOx) into molecular nitrogen (N2) and water vapor (H2O). The SCR utilizes a catalyst to increase the NOx removal efficiency, which allows the process to occur at lower temperatures.

This control is applicable to small (40 to 174 MMBtu/hr) other (not classified) fuel-fired process heaters with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

30600199 Process Heaters, Other Not Classified

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 91% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by power output (Pechan, 1998).

Small source = 40 to 174 MMBtu/hr

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). The basis of the costs are model plant data in the Alternative Control Techniques (ACT) document (EPA, 1993). From this analysis, default cost per ton values are assigned along with a capital to annual costs ratio of 6.6. A discount rate of 10 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 15 years (EPA, 1993).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 55% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown is estimated using the detailed information in Table 6-4 and Ch. 6 of the Process Heaters ACT. The breakdown was obtained using the O&M costs for a mechanical draft process heater fired on residual fuel and having a capacity of 69 MMBTU per hour. The cost percentage is applied to heaters fired on other fuel via technology transfer (Pechan, 1998). A capacity factor

AT-A-GLANCE TABLE FOR POINT SOURCES

of 0.58 is used in estimating the O&M cost breakdown.

Electricity: \$0.06 per kw-hr

Fuel (residual oil): \$3.00 per MMBTU

Ammonia: \$0.125 per lb

Cost Effectiveness: The default cost effectiveness values are \$5,420 per ton NO_x reduced from uncontrolled and \$7,680 per ton NO_x reduced from RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

Cost equations for NO_x control of process heaters firing other fuel are based on an analysis of EPA's NO_x State Implementation Plan (SIP) Call (Pechan-Avanti, 1998). Applicable control technologies and costs are assumed to be similar to process heaters firing residual oil. LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNB's create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNB's create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

Selective Catalytic Reduction (SCR) has been widely applied to stationary source, fossil fuel-fired, combustion units for emission control since the early 1970s. SCR is typically implemented on units requiring a higher level of NO_x control than achievable by SNCR or other combustion controls (EPA, 2002).

Like SNCR, SCR is based on the chemical reduction of the NO_x molecule. The primary difference between SNCR and SCR is that SCR uses a metal-based catalyst to increase the rate of reaction (EPA, 2002). A nitrogen based reducing reagent, such as ammonia or urea, is injected into the flue gas. The reagent reacts selectively with the flue gas NO_x within a specific temperature range and in the presence of the catalyst and oxygen to reduce the NO_x.

The use of a catalyst results in two advantages of the SCR process over SNCR, the higher NO_x reduction efficiency and the lower and broader temperature ranges. However, the decrease in reaction temperature and increase in efficiency is accompanied by a significant increase in capital and operating costs (EPA, 2002). The cost increase is due to the large amount of catalyst required.

The SCR system can utilize either aqueous or anhydrous ammonia as the reagent. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Today, catalyst formulations include single component, multi-component, or active phase with a support structure. Most catalyst formulations contain additional compounds or supports, providing thermal and structural stability or to increase surface area (EPA, 2002).

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include: reaction temperature range; residence time available in the optimum temperature range; degree of mixing between the injected

AT-A-GLANCE TABLE FOR POINT SOURCES

reagent and the combustion gases; uncontrolled NO_x concentration level; molar ratio of injected reagent to uncontrolled NO_x; ammonia slip; catalyst activity; catalyst selectivity; pressure drop across the catalyst; catalyst pitch; catalyst deactivation; and catalyst management (EPA, 2001).

References:

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Process Heaters," EPA,-453/R-93-034, Research Triangle Park, NC, September 1993.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Process Heaters - Process Gas - Small Sources

Control Measure Name: Low NOx Burner

Rule Name: Not Applicable

Pechan Measure Code: N0471S, N04701

POD: 47

Application: This control is the use of low NOx burner (LNB) technology to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another.

This control is applicable to small (40 to 174 MMBtu/hr) process gas-fired process heaters with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

30190004 Fuel Fired Equipment, Process Gas: Process Heaters

30600106 Process Heaters, Process Gas-fired

31000405 Process Heaters, Process Gas

31000415 Process Heaters, Process Gas: Steam Generators

39990004 Miscellaneous Manufacturing Industries, Process Gas: Process Heaters

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 50% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by power output (Pechan, 1998).

Small source = 40 to 174 MMBtu/hr

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). The basis of the costs are model plant data for mechanical draft heaters firing natural gas and oil contained in the Alternative Control Techniques (ACT) document (EPA, 1993). From this analysis, default cost per ton values are assigned along with a capital to annual costs ratio of 7.3. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 15 years (EPA, 1993).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 55% (Pechan, 2001).

Cost Effectiveness: The default cost effectiveness value used in AirControlINET is \$2,200 per ton NOx reduced from both uncontrolled and RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNBs create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNBs create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

References:

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Process Heaters," EPA-453/R-93-034, Research Triangle Park, NC, September 1993.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Process Heaters - Process Gas - Small Sources

Control Measure Name: Low NOx Burner + Flue Gas Recirculation

Rule Name: Not Applicable

Pechan Measure Code: N0472S, N04702

POD: 47

Application: This control is the use of low NOx burner (LNB) technology and flue gas recirculation (FGR) to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another.

This control is applicable to small (40 to 174 MMBtu/hr) process gas-fired process heaters with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

30190004 Fuel Fired Equipment, Process Gas: Process Heaters

30600106 Process Heaters, Process Gas-fired

31000405 Process Heaters, Process Gas

31000415 Process Heaters, Process Gas: Steam Generators

39990004 Miscellaneous Manufacturing Industries, Process Gas: Process Heaters

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 55% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by power output (Pechan, 1998).

Small source = 40 to 174 MMBtu/hr

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). The basis of the costs are model plant data in the Alternative Control Techniques (ACT) document (EPA, 1993). From this analysis, default cost per ton values are assigned along with a capital to annual costs ratio of 6.9. A discount rate of 10 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 15 years (EPA, 1993).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 55% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown is estimated using the detailed information in Table 6-3 and Ch. 6 of the Process Heaters ACT. The breakdown was obtained using the O&M costs for a mechanical draft process heater fired on natural gas and having a capacity of 77 MMBTU per hour. The cost percentage is applied to heaters fired on process gas via technology transfer (Pechan, 1998). A capacity factor of 0.5 is used in estimating the O&M cost breakdown.

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Electricity: \$0.06 per kw-hr

Cost Effectiveness: The default cost effectiveness values are \$3,190 per ton NO_x reduced from uncontrolled and \$15,580 per ton NO_x reduced from RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNBs create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNBs create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

References:

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Process Heaters," EPA-453/R-93-034, Research Triangle Park, NC, September 1993.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Process Heaters - Process Gas - Small Sources

Control Measure Name: Selective Non-Catalytic Reduction (SNCR)

Rule Name: Not Applicable

Pechan Measure Code: N0473S, N04703

POD: 47

Application: This control is the reduction of NO_x emission through selective non-catalytic reduction add-on controls. SNCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NO_x) into molecular nitrogen (N₂) and water vapor (H₂O).

This control applies to small (<1 ton NO_x emissions per OSD) process gas fired process heaters with uncontrolled NO_x emissions greater than 10 tons per year.

Affected SCC:

30190004 Fuel Fired Equipment, Process Gas: Process Heaters

30600106 Process Heaters, Process Gas-fired

31000405 Process Heaters, Process Gas

31000415 Process Heaters, Process Gas: Steam Generators

39990004 Miscellaneous Manufacturing Industries, Process Gas: Process Heaters

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 60% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NO_x emission levels (Pechan, 1998).

Small source = emission levels less than 1 ton per ozone season day

Costs for stationary source NO_x control are based on an analysis of EPA's NO_x State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned for small sources. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 15 years (EPA, 1993).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 55% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown is estimated using the detailed information in Table 6-3 and Ch. 6 of the Process Heaters ACT. The breakdown was obtained using the O&M costs for a mechanical draft process heater fired on natural gas and having a capacity of 77 MMBTU per hour. The cost percentage is applied to heaters fired on process gas via technology transfer (Pechan, 1998). A capacity factor of 0.5 is used in estimating the O&M cost breakdown.

AT-A-GLANCE TABLE FOR POINT SOURCES

Electricity: \$0.06 per kw-hr
Fuel (natural gas): \$2.00 per MMBTU
Ammonia: \$0.125 per lb

Cost Effectiveness: The cost effectiveness used in AirControlNET for both reductions from baseline and reductions from RACT is \$2,850 per ton NOx reduced (1990\$).

Comments:

Status: Demonstrated	Last Reviewed: 2001
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Additional Information:

SNCR is the reduction of NOx in flue gas to N2 and water vapor. This reduction is done with a nitrogen based reducing reagent, such as ammonia or urea. The reagent can react with a number of flue gas components. However, the NOx reduction reaction is favored for a specific temperature range and in the presence of oxygen (EPA, 2002).

Both ammonia and urea are used as reagents. The cost of the reagent represents a large part of the annual costs of an SNCR system. Ammonia is generally less expensive than urea. However, the choice of reagent is also based on physical properties and operational considerations (EPA, 2002).

Ammonia can be utilized in either aqueous or anhydrous form. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Urea based systems have several advantages, including several safety aspects. Urea is a nontoxic, less volatile liquid that can be stored and handled more safely than ammonia. Urea solution droplets can penetrate farther into the flue gas when injected into the boiler, enhancing mixing (EPA, 2002). Because of these advantages, urea is more commonly used than ammonia in large boiler applications.

The rate of reaction determines the amount of NOx removed from the flue gas. The important design and operational factors that affect the rate of reduction include:

Reaction temperature range;
Residence time available in the optimum temperature range;
Degree of mixing between the injected reagent and the combustion gases
Uncontrolled NOx concentration level;
Molar ratio of injected reagent to uncontrolled NOx ; and
Ammonia slip.

References:

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Process Heaters," EPA,-453/R-93-034, Research Triangle Park, NC, September 1993.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air

AT-A-GLANCE TABLE FOR POINT SOURCES

Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Process Heaters - Process Gas - Small Sources

Control Measure Name: Ultra Low NOx Burner

Rule Name: Not Applicable

Pechan Measure Code: N0474S, N04704

POD: 47

Application: This control is the use of ultra-low NOx burner (ULNB) add-on technologies to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another. SCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NOx) into molecular nitrogen (N₂) and water vapor (H₂O).

This control applies to small (40 to 174 MMBtu/hr) process gas-fired process heaters with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

30190004 Fuel Fired Equipment, Process Gas: Process Heaters

30490004 Fuel Fired Equipment, Process Gas: Process Heaters

30600106 Process Heaters, Process Gas-fired

31000405 Process Heaters, Process Gas

31000415 Process Heaters, Process Gas: Steam Generators

39990004 Miscellaneous Manufacturing Industries, Process Gas: Process Heaters

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 75% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by power output (Pechan, 1998).

Small source = 40 to 174 MMBtu/hr

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned along with a capital to annual costs ratio of 7.3. A discount rate of 10 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 15 years (EPA, 1993).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 55% (Pechan, 2001).

Cost Effectiveness: The default cost effectiveness value is \$1,500 per ton NOx reduced from both uncontrolled and RACT baselines (1990\$).

Comments:

AT-A-GLANCE TABLE FOR POINT SOURCES

Status: Demonstrated	Last Reviewed: 2001
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Additional Information:

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNBs create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNBs create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

References:

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Process Heaters," EPA-453/R-93-034, Research Triangle Park, NC, September 1993.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Process Heaters - Process Gas - Small Sources

Control Measure Name: Selective Catalytic Reduction (SCR)

Rule Name: Not Applicable

Pechan Measure Code: N0475S, N04705

POD: 47

Application: This control is the selective catalytic reduction of NOx through add-on controls. SCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NOx) into molecular nitrogen (N₂) and water vapor (H₂O). The SCR utilizes a catalyst to increase the NOx removal efficiency, which allows the process to occur at lower temperatures.

Applies to small (<1 ton NOx per OSD) process gas process heaters with NOx emissions greater than 10 tons per year.

Affected SCC:

30190004 Fuel Fired Equipment, Process Gas: Process Heaters

30490004 Fuel Fired Equipment, Process Gas: Process Heaters

30600106 Process Heaters, Process Gas-fired

31000405 Process Heaters, Process Gas

31000415 Process Heaters, Process Gas: Steam Generators

39990004 Miscellaneous Manufacturing Industries, Process Gas: Process Heaters

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 75% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NOx emission levels (Pechan, 1998).

Small source = emission levels less than 1 ton per ozone season day

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 15 years (EPA, 1993).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 55% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown is estimated using the detailed information in Table 6-3 and Ch. 6 of the Process Heaters ACT. The breakdown was obtained using the O&M costs for a mechanical draft process heater fired on natural gas and having a capacity of 77 MMBTU per hour. The cost percentage is applied to heaters fired on process gas via technology transfer (Pechan, 1998). A capacity factor of 0.5 is used in estimating the O&M cost breakdown.

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Electricity: \$0.06 per kw-hr
Fuel (natural gas): \$2.00 per MMBTU
Ammonia: \$0.125 per lb

Cost Effectiveness: The cost effectiveness value used in AirControlNET is \$12,040 per ton NO_x reduced from both uncontrolled and RACT baselines (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

Selective Catalytic Reduction (SCR) has been widely applied to stationary source, fossil fuel-fired, combustion units for emission control since the early 1970s. SCR is typically implemented on units requiring a higher level of NO_x control than achievable by SNCR or other combustion controls (EPA, 2002).

Like SNCR, SCR is based on the chemical reduction of the NO_x molecule. The primary difference between SNCR and SCR is that SCR uses a metal-based catalyst to increase the rate of reaction (EPA, 2002). A nitrogen based reducing reagent, such as ammonia or urea, is injected into the flue gas. The reagent reacts selectively with the flue gas NO_x within a specific temperature range and in the presence of the catalyst and oxygen to reduce the NO_x.

The use of a catalyst results in two advantages of the SCR process over SNCR, the higher NO_x reduction efficiency and the lower and broader temperature ranges. However, the decrease in reaction temperature and increase in efficiency is accompanied by a significant increase in capital and operating costs (EPA, 2002). The cost increase is due to the large amount of catalyst required.

The SCR system can utilize either aqueous or anhydrous ammonia as the reagent. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Today, catalyst formulations include single component, multi-component, or active phase with a support structure. Most catalyst formulations contain additional compounds or supports, providing thermal and structural stability or to increase surface area (EPA, 2002).

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include: reaction temperature range; residence time available in the optimum temperature range; degree of mixing between the injected reagent and the combustion gases; uncontrolled NO_x concentration level; molar ratio of injected reagent to uncontrolled NO_x; ammonia slip; catalyst activity; catalyst selectivity; pressure drop across the catalyst; catalyst pitch; catalyst deactivation; and catalyst management (EPA, 2001).

References:

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Process Heaters," EPA-453/R-93-034, Research Triangle Park, NC, September 1993.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC,

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January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Process Heaters - Process Gas - Small Sources

Control Measure Name: Low NOx Burner (LNB) +Selective Reduction SNCR

Rule Name: Not Applicable

Pechan Measure Code: N0476S, N04706

POD: 47

Application: This control is the use of low NOx burner (LNB) technology and selective non-catalytic reduction (SNCR) to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another. SNCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NOx) into molecular nitrogen (N2) and water vapor (H2O).

This control is applicable to small (40 to 174 MMBtu/hr) process gas-fired process heaters with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

30190004 Fuel Fired Equipment, Process Gas: Process Heaters

30490004 Fuel Fired Equipment, Process Gas: Process Heaters

30600106 Process Heaters, Process Gas-fired

31000405 Process Heaters, Process Gas

31000415 Process Heaters, Process Gas: Steam Generators

39990004 Miscellaneous Manufacturing Industries, Process Gas: Process Heaters

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 80% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by power output (Pechan, 1998).

Small source = 40 to 174 MMBtu/hr

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). The basis of the costs are model plant data in the Alternative Control Techniques (ACT) document (EPA, 1993). From this analysis, default cost per ton values are assigned along with a capital to annual costs ratio of 6.7. A discount rate of 10 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 15 years (EPA, 1993).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 55% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown is estimated using the detailed information in Table 6-3 and Ch. 6 of the Process Heaters ACT. The breakdown was obtained using the O&M costs for a mechanical draft process heater fired on natural

AT-A-GLANCE TABLE FOR POINT SOURCES

gas and having a capacity of 77 MMBTU per hour. The cost percentage is applied to heaters fired on process gas via technology transfer (Pechan, 1998). A capacity factor of 0.5 is used in estimating the O&M cost breakdown.

Electricity: \$0.06 per kw-hr

Fuel (natural gas): \$2.00 per MMBTU

Ammonia: \$0.125 per lb

Cost Effectiveness: The default cost effectiveness values are \$3,520 per ton NO_x reduced from uncontrolled and \$6,600 per ton NO_x reduced from RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNB's create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNB's create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

SNCR is the reduction of NO_x in flue gas to N₂ and water vapor. This reduction is done with a nitrogen based reducing reagent, such as ammonia or urea. The reagent can react with a number of flue gas components. However, the NO_x reduction reaction is favored for a specific temperature range and in the presence of oxygen (EPA, 2002).

Both ammonia and urea are used as reagents. The cost of the reagent represents a large part of the annual costs of an SNCR system. Ammonia is generally less expensive than urea. However, the choice of reagent is also based on physical properties and operational considerations (EPA, 2002).

Ammonia can be utilized in either aqueous or anhydrous form. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Urea based systems have several advantages, including several safety aspects. Urea is a nontoxic, less volatile liquid that can be stored and handled more safely than ammonia. Urea solution droplets can penetrate farther into the flue gas when injected into the boiler, enhancing mixing (EPA, 2002). Because of these advantages, urea is more commonly used than ammonia in large boiler applications.

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include:

Reaction temperature range;

Residence time available in the optimum temperature range;

Degree of mixing between the injected reagent and the combustion gases

Uncontrolled NO_x concentration level;

Molar ratio of injected reagent to uncontrolled NO_x ; and

Ammonia slip.

AT-A-GLANCE TABLE FOR POINT SOURCES

References:

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Process Heaters," EPA,-453/R-93-034, Research Triangle Park, NC, September 1993.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Process Heaters - Process Gas - Small Sources

Control Measure Name: Low NOx Burner (LNB) + Selective Catalytic Reduction (SCR)

Rule Name: Not Applicable

Pechan Measure Code: N0477S, N04707

POD: 47

Application: This control is the use of low NOx burner (LNB) technology and selective catalytic reduction (SCR) to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another. SCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NOx) into molecular nitrogen (N₂) and water vapor (H₂O). The SCR utilizes a catalyst to increase the NOx removal efficiency, which allows the process to occur at lower temperatures.

This control is applicable to small (40 to 174 MMBtu/hr) process gas-fired process heaters with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

30190004 Fuel Fired Equipment, Process Gas: Process Heaters
30490004 Fuel Fired Equipment, Process Gas: Process Heaters
30600106 Process Heaters, Process Gas-fired
31000405 Process Heaters, Process Gas
31000415 Process Heaters, Process Gas: Steam Generators
39990004 Miscellaneous Manufacturing Industries, Process Gas: Process Heaters

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 88% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by power output (Pechan, 1998).

Small source = 40 to 174 MMBtu/hr

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). The basis of the costs are model plant data in the Alternative Control Techniques (ACT) document (EPA, 1993). From this analysis, default cost per ton values are assigned along with a capital to annual costs ratio of 6.8. A discount rate of 10 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 15 years (EPA, 1993).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 55% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown is estimated using the detailed

AT-A-GLANCE TABLE FOR POINT SOURCES

information in Table 6-3 and Ch. 6 of the ACT for Process Heaters. The breakdown was obtained using the O&M costs for a mechanical draft process heater having a capacity of 77 MMBTU per hour fired on natural gas. The cost percentage is applied to heaters fired on process gas via technology transfer (Pechan, 1998). A capacity factor of 0.5 is used in estimating the O&M cost breakdown.

Electricity: \$0.06 per kw-hr

Fuel (natural gas): \$2.00 per MMBTU

Ammonia: \$0.125 per lb

Cost Effectiveness: The default cost effectiveness values are \$11,560 per ton NO_x reduced from uncontrolled and \$27,910 per ton NO_x reduced from RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNB's create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNB's create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

Selective Catalytic Reduction (SCR) has been widely applied to stationary source, fossil fuel-fired, combustion units for emission control since the early 1970s. SCR is typically implemented on units requiring a higher level of NO_x control than achievable by SNCR or other combustion controls (EPA, 2002).

Like SNCR, SCR is based on the chemical reduction of the NO_x molecule. The primary difference between SNCR and SCR is that SCR uses a metal-based catalyst to increase the rate of reaction (EPA, 2002). A nitrogen based reducing reagent, such as ammonia or urea, is injected into the flue gas. The reagent reacts selectively with the flue gas NO_x within a specific temperature range and in the presence of the catalyst and oxygen to reduce the NO_x.

The use of a catalyst results in two advantages of the SCR process over SNCR, the higher NO_x reduction efficiency and the lower and broader temperature ranges. However, the decrease in reaction temperature and increase in efficiency is accompanied by a significant increase in capital and operating costs (EPA, 2002). The cost increase is due to the large amount of catalyst required.

The SCR system can utilize either aqueous or anhydrous ammonia as the reagent. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Today, catalyst formulations include single component, multi-component, or active phase with a support structure. Most catalyst formulations contain additional compounds or supports, providing thermal and structural stability or to increase surface area (EPA, 2002).

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include: reaction temperature range;

AT-A-GLANCE TABLE FOR POINT SOURCES

residence time available in the optimum temperature range; degree of mixing between the injected reagent and the combustion gases; uncontrolled NO_x concentration level; molar ratio of injected reagent to uncontrolled NO_x; ammonia slip; catalyst activity; catalyst selectivity; pressure drop across the catalyst; catalyst pitch; catalyst deactivation; and catalyst management (EPA, 2001).

References:

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Process Heaters," EPA,-453/R-93-034, Research Triangle Park, NC, September 1993.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Process Heaters - Residual Oil - Small Sources

Control Measure Name: Low NOx Burner + Flue Gas Recirculation

Rule Name: Not Applicable

Pechan Measure Code: N0261S, N02601

POD: 26

Application: This control is the use of low NOx burner (LNB) technology and flue gas recirculation (FGR) to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another.

This control is applicable to small (40 to 174 MMBtu/hr) residual oil-fired process heaters with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

30190002 Fuel Fired Equipment, Residual Oil: Process Heaters

30590002 Fuel Fired Equipment, Residual Oil: Process Heaters

30790002 Fuel Fired Equipment, Residual Oil: Process Heaters

31000403 Process Heaters, Crude Oil

39990002 Miscellaneous Manufacturing Industries, Residual Oil: Process Heaters

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√/*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 34% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NOx emissions (Pechan, 1998).

Small source = less than 1 ton NOx emissions per ozone season day

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). The basis of the costs are model plant data for mechanical draft heaters firing natural gas and oil contained in the Alternative Control Techniques (ACT) document (EPA, 1993). From this analysis, default cost per ton values are assigned along with a capital to annual costs ratio of 7.1. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 10 years (EPA, 1993).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies greater than 26% and less than or equal to 55% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown is estimated using the detailed information in Table 6-4 and Ch. 6 of the Process Heaters ACT. The breakdown was obtained using the O&M costs for a mechanical draft process heater having a capacity of 69 MMBTU per hour. A capacity factor of 0.58 is used in estimating the

AT-A-GLANCE TABLE FOR POINT SOURCES

O&M cost breakdown.

Electricity: \$0.06 per kw-hr

Cost Effectiveness: The default cost effectiveness value is \$3,490 per ton NO_x reduced from both uncontrolled and RACT baselines (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNBs create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNBs create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

References:

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Process Heaters," EPA-453/R-93-034, Research Triangle Park, NC, September 1993.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Process Heaters - Residual Oil - Small Sources

Control Measure Name: Low NOx Burner

Rule Name: Not Applicable

Pechan Measure Code: N0262S, N02602

POD: 26

Application: This control is the use of low NOx burner (LNB) technology to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another.

This control is applicable to small (40 to 174 MMBtu/hr) residual oil-fired process heaters with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

30190002 Fuel Fired Equipment, Residual Oil: Process Heaters

30590002 Fuel Fired Equipment, Residual Oil: Process Heaters

30790002 Fuel Fired Equipment, Residual Oil: Process Heaters

31000403 Process Heaters, Crude Oil

39990002 Miscellaneous Manufacturing Industries, Residual Oil: Process Heaters

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√/*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 37% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by power output (Pechan, 1998).

Small source = 40 to 174 MMBtu/hr

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). The basis of the costs are model plant data for mechanical draft heaters firing natural gas and oil contained in the Alternative Control Techniques (ACT) document (EPA, 1993). From this analysis, default cost per ton values are assigned along with a capital to annual costs ratio of 7.3. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 15 years (EPA, 1993).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies greater than 26% and less than or equal to 55% (Pechan, 2001).

Cost Effectiveness: The default cost effectiveness value used in AirControlINET is \$2,520 per ton NOx reduced from both uncontrolled and RACT (1990\$).

Comments:

AT-A-GLANCE TABLE FOR POINT SOURCES

Status: Demonstrated	Last Reviewed: 2001
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Additional Information:

LNBS are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNBS create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNBS create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

References:

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Process Heaters," EPA-453/R-93-034, Research Triangle Park, NC, September 1993.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Process Heaters - Residual Oil - Small Sources

Control Measure Name: Selective Non-Catalytic Reduction (SNCR)

Rule Name: Not Applicable

Pechan Measure Code: N0263S, N02603

POD: 26

Application: This control is the reduction of NO_x emission through selective non-catalytic reduction add-on controls. SNCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NO_x) into molecular nitrogen (N₂) and water vapor (H₂O).

This control applies to small (<1 ton NO_x emissions per OSD) residual oil-fired process heaters with uncontrolled NO_x emissions greater than 10 tons per year.

Affected SCC:

30190002 Fuel Fired Equipment, Residual Oil: Process Heaters

30590002 Fuel Fired Equipment, Residual Oil: Process Heaters

30790002 Fuel Fired Equipment, Residual Oil: Process Heaters

31000403 Process Heaters, Crude Oil

39990002 Miscellaneous Manufacturing Industries, Residual Oil: Process Heaters

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 60% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NO_x emission levels (Pechan, 1998).

Small source = emission levels less than 1 ton per ozone season day

Costs for stationary source NO_x control are based on an analysis of EPA's NO_x State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned for small sources. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 15 years (EPA, 1993).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies greater than 26% and less than or equal to 55% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown is estimated using the detailed information in Table 6-4 and Ch. 6 of the Process Heaters ACT. The breakdown was obtained using the O&M costs for a mechanical draft process heater having a capacity of 69 MMBTU per hour. A capacity factor of 0.58 is used in estimating the O&M cost breakdown.

AT-A-GLANCE TABLE FOR POINT SOURCES

Electricity: \$0.06 per kw-hr
Fuel (residual oil): \$3.00 per MMBTU
Ammonia: \$0.125 per lb

Cost Effectiveness: The cost effectiveness used in AirControlNET for both reductions from baseline and reductions from RACT is \$1,930 per ton NOx reduced (1990\$).

Comments:

Status: Demonstrated	Last Reviewed: 2001
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Additional Information:

SNCR is the reduction of NOx in flue gas to N2 and water vapor. This reduction is done with a nitrogen based reducing reagent, such as ammonia or urea. The reagent can react with a number of flue gas components. However, the NOx reduction reaction is favored for a specific temperature range and in the presence of oxygen (EPA, 2002).

Both ammonia and urea are used as reagents. The cost of the reagent represents a large part of the annual costs of an SNCR system. Ammonia is generally less expensive than urea. However, the choice of reagent is also based on physical properties and operational considerations (EPA, 2002).

Ammonia can be utilized in either aqueous or anhydrous form. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Urea based systems have several advantages, including several safety aspects. Urea is a nontoxic, less volatile liquid that can be stored and handled more safely than ammonia. Urea solution droplets can penetrate farther into the flue gas when injected into the boiler, enhancing mixing (EPA, 2002). Because of these advantages, urea is more commonly used than ammonia in large boiler applications.

The rate of reaction determines the amount of NOx removed from the flue gas. The important design and operational factors that affect the rate of reduction include:

Reaction temperature range;
Residence time available in the optimum temperature range;
Degree of mixing between the injected reagent and the combustion gases
Uncontrolled NOx concentration level;
Molar ratio of injected reagent to uncontrolled NOx ; and ammonia slip.

References:

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Process Heaters," EPA-453/R-93-034, Research Triangle Park, NC, September 1993.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle

AT-A-GLANCE TABLE FOR POINT SOURCES

Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Process Heaters - Residual Oil - Small Sources

Control Measure Name: Ultra Low NOx Burner

Rule Name: Not Applicable

Pechan Measure Code: N0264S, N02604

POD: 26

Application: This control is the use of ultra-low NOx burner (ULNB) add-on technologies to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another. SCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NOx) into molecular nitrogen (N₂) and water vapor (H₂O).

This control applies to small (40 to 174 MMBtu/hr) residual oil-fired process heaters with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

30190002 Fuel Fired Equipment, Residual Oil: Process Heaters

30590002 Fuel Fired Equipment, Residual Oil: Process Heaters

30790002 Fuel Fired Equipment, Residual Oil: Process Heaters

31000403 Process Heaters, Crude Oil

39990002 Miscellaneous Manufacturing Industries, Residual Oil: Process Heaters

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 73% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by power output (Pechan, 1998).

Small source = 40 to 174 MMBtu/hr

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned along with a capital to annual costs ratio of 7.3. A discount rate of 10 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 15 years (EPA, 1993).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies greater than 26% and less than or equal to 55% (Pechan, 2001).

Cost Effectiveness: The default cost effectiveness value is \$1,290 per ton NOx reduced from both uncontrolled and RACT baselines (1990\$).

Comments:

AT-A-GLANCE TABLE FOR POINT SOURCES

Status: Demonstrated	Last Reviewed: 2001
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Additional Information:

LNBS are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNBS create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNBS create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

References:

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Process Heaters," EPA-453/R-93-034, Research Triangle Park, NC, September 1993.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Process Heaters - Residual Oil - Small Sources

Control Measure Name: Low NOx Burner (LNB) + SCR

Rule Name: Not Applicable

Pechan Measure Code: N0265S, N02605

POD: 26

Application: This control is the use of low NOx burner (LNB) technology and selective non-catalytic reduction (SNCR) to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another. SNCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NOx) into molecular nitrogen (N2) and water vapor (H2O).

This control is applicable to small (40 to 174 MMBtu/hr) residual-fired process heaters with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

30190002 Fuel Fired Equipment, Residual Oil: Process Heaters

30590002 Fuel Fired Equipment, Residual Oil: Process Heaters

30790002 Fuel Fired Equipment, Residual Oil: Process Heaters

31000403 Process Heaters, Crude Oil

39990002 Miscellaneous Manufacturing Industries, Residual Oil: Process Heaters

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 75% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by power output (Pechan, 1998).

Small source = 40 to 174 MMBtu/hr

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). The basis of the costs are model plant data in the Alternative Control Techniques (ACT) document (EPA, 1993). From this analysis, default cost per ton values are assigned along with a capital to annual costs ratio of 6.4. A discount rate of 10 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 15 years (EPA, 1993).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies greater than 26% and less than or equal to 55% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown is estimated using the detailed information in Table 6-4 and Ch. 6 of the Process Heaters ACT. The breakdown was obtained using the O&M costs for a mechanical draft process heater having a

AT-A-GLANCE TABLE FOR POINT SOURCES

capacity of 69 MMBTU per hour. A capacity factor of 0.58 is used in estimating the O&M cost breakdown.

Electricity: \$0.06 per kw-hr

Fuel (residual oil): \$3.00 per MMBTU

Ammonia: \$0.125 per lb

Cost Effectiveness: The default cost effectiveness values are \$2,300 per ton NO_x reduced from uncontrolled and \$2,080 per ton NO_x reduced from RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNB's create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNB's create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

SNCR is the reduction of NO_x in flue gas to N₂ and water vapor. This reduction is done with a nitrogen based reducing reagent, such as ammonia or urea. The reagent can react with a number of flue gas components. However, the NO_x reduction reaction is favored for a specific temperature range and in the presence of oxygen (EPA, 2002).

Both ammonia and urea are used as reagents. The cost of the reagent represents a large part of the annual costs of an SNCR system. Ammonia is generally less expensive than urea. However, the choice of reagent is also based on physical properties and operational considerations (EPA, 2002).

Ammonia can be utilized in either aqueous or anhydrous form. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Urea based systems have several advantages, including several safety aspects. Urea is a nontoxic, less volatile liquid that can be stored and handled more safely than ammonia. Urea solution droplets can penetrate farther into the flue gas when injected into the boiler, enhancing mixing (EPA, 2002). Because of these advantages, urea is more commonly used than ammonia in large boiler applications.

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include:

Reaction temperature range;

Residence time available in the optimum temperature range;

Degree of mixing between the injected reagent and the combustion gases

Uncontrolled NO_x concentration level;

Molar ratio of injected reagent to uncontrolled NO_x ; and ammonia slip.

AT-A-GLANCE TABLE FOR POINT SOURCES

References:

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Process Heaters," EPA,-453/R-93-034, Research Triangle Park, NC, September 1993.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Process Heaters - Residual Oil - Small Sources

Control Measure Name: Selective Catalytic Reduction (SCR)

Rule Name: Not Applicable

Pechan Measure Code: N0266S, N02606

POD: 26

Application: This control is the selective catalytic reduction of NO_x through add-on controls. SCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NO_x) into molecular nitrogen (N₂) and water vapor (H₂O). The SCR utilizes a catalyst to increase the NO_x removal efficiency, which allows the process to occur at lower temperatures.

Applies to small (<1 ton NO_x per OSD) residual oil-fired process heaters with NO_x emissions greater than 10 tons per year.

Affected SCC:

30190002 Fuel Fired Equipment, Residual Oil: Process Heaters

30590002 Fuel Fired Equipment, Residual Oil: Process Heaters

30790002 Fuel Fired Equipment, Residual Oil: Process Heaters

31000403 Process Heaters, Crude Oil

39990002 Miscellaneous Manufacturing Industries, Residual Oil: Process Heaters

Pollutant(s)	PM10	PM2.5	EC	OC	NO _x	VOC	SO ₂	NH ₃	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 75% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NO_x emission levels (Pechan, 1998).

Small source = emission levels less than 1 ton per ozone season day

Costs for stationary source NO_x control are based on an analysis of EPA's NO_x State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 15 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies greater than 26% and less than or equal to 55% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown is estimated using the detailed information in Table 6-4 and Ch. 6 of the Process Heaters ACT. The breakdown was obtained using the O&M costs for a mechanical draft process heater having a capacity of 69 MMBTU per hour. A capacity factor of 0.58 is used in estimating the O&M cost breakdown.

AT-A-GLANCE TABLE FOR POINT SOURCES

Electricity: \$0.06 per kw-hr
Fuel (residual oil): \$3.00 per MMBTU
Ammonia: \$0.125 per lb

Cost Effectiveness: The cost effectiveness value used in AirControlNET is \$5,350 per ton NO_x reduced from both uncontrolled and RACT baselines (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

Selective Catalytic Reduction (SCR) has been widely applied to stationary source, fossil fuel-fired, combustion units for emission control since the early 1970s. SCR is typically implemented on units requiring a higher level of NO_x control than achievable by SNCR or other combustion controls (EPA, 2002).

Like SNCR, SCR is based on the chemical reduction of the NO_x molecule. The primary difference between SNCR and SCR is that SCR uses a metal-based catalyst to increase the rate of reaction (EPA, 2002). A nitrogen based reducing reagent, such as ammonia or urea, is injected into the flue gas. The reagent reacts selectively with the flue gas NO_x within a specific temperature range and in the presence of the catalyst and oxygen to reduce the NO_x.

The use of a catalyst results in two advantages of the SCR process over SNCR, the higher NO_x reduction efficiency and the lower and broader temperature ranges. However, the decrease in reaction temperature and increase in efficiency is accompanied by a significant increase in capital and operating costs (EPA, 2002). The cost increase is due to the large amount of catalyst required.

The SCR system can utilize either aqueous or anhydrous ammonia as the reagent. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Today, catalyst formulations include single component, multi-component, or active phase with a support structure. Most catalyst formulations contain additional compounds or supports, providing thermal and structural stability or to increase surface area (EPA, 2002).

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include: reaction temperature range; residence time available in the optimum temperature range; degree of mixing between the injected reagent and the combustion gases; uncontrolled NO_x concentration level; molar ratio of injected reagent to uncontrolled NO_x; ammonia slip; catalyst activity; catalyst selectivity; pressure drop across the catalyst; catalyst pitch; catalyst deactivation; and catalyst management (EPA, 2001).

References:

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Process Heaters," EPA-453/R-93-034, Research Triangle Park, NC, September 1993.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

AT-A-GLANCE TABLE FOR POINT SOURCES

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Process Heaters - Residual Oil - Small Sources

Control Measure Name: Low NOx Burner (LNB) + Selective Catalytic Reduction (SCR)

Rule Name: Not Applicable

Pechan Measure Code: N0267S, N02607

POD: 26

Application: This control is the use of low NOx burner (LNB) technology and selective catalytic reduction (SCR) to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another. SCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NOx) into molecular nitrogen (N₂) and water vapor (H₂O). The SCR utilizes a catalyst to increase the NOx removal efficiency, which allows the process to occur at lower temperatures.

This control is applicable to small (40 to 174 MMBtu/hr) residual oil-fired process heaters with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

30190002 Fuel Fired Equipment, Residual Oil: Process Heaters

30590002 Fuel Fired Equipment, Residual Oil: Process Heaters

30790002 Fuel Fired Equipment, Residual Oil: Process Heaters

31000403 Process Heaters, Crude Oil

39990002 Miscellaneous Manufacturing Industries, Residual Oil: Process Heaters

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 91% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by power output (Pechan, 1998).

Small source = 40 to 174 MMBtu/hr

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). The basis of the costs are model plant data in the Alternative Control Techniques (ACT) document (EPA, 1993). From this analysis, default cost per ton values are assigned along with a capital to annual costs ratio of 6.6. A discount rate of 10 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 15 years (EPA, 1993).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies greater than 26% and less than or equal to 55% (Pechan, 2001).

O&M Cost Components: The O&M cost breakdown is estimated using the detailed

AT-A-GLANCE TABLE FOR POINT SOURCES

information in Table 6-4 and Ch. 6 of the Process Heaters ACT. The breakdown was obtained using the O&M costs for a mechanical draft process heater having a capacity of 69 MMBTU per hour. A capacity factor of 0.58 is used in estimating the O&M cost breakdown.

Electricity: \$0.06 per kw-hr

Fuel (residual oil): \$3.00 per MMBTU

Ammonia: \$0.125 per lb

Cost Effectiveness: The default cost effectiveness values are \$5,420 per ton NO_x reduced from uncontrolled and \$7,680 per ton NO_x reduced from RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNB's create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNB's create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

Selective Catalytic Reduction (SCR) has been widely applied to stationary source, fossil fuel-fired, combustion units for emission control since the early 1970s. SCR is typically implemented on units requiring a higher level of NO_x control than achievable by SNCR or other combustion controls (EPA, 2002).

Like SNCR, SCR is based on the chemical reduction of the NO_x molecule. The primary difference between SNCR and SCR is that SCR uses a metal-based catalyst to increase the rate of reaction (EPA, 2002). A nitrogen based reducing reagent, such as ammonia or urea, is injected into the flue gas. The reagent reacts selectively with the flue gas NO_x within a specific temperature range and in the presence of the catalyst and oxygen to reduce the NO_x.

The use of a catalyst results in two advantages of the SCR process over SNCR, the higher NO_x reduction efficiency and the lower and broader temperature ranges. However, the decrease in reaction temperature and increase in efficiency is accompanied by a significant increase in capital and operating costs (EPA, 2002). The cost increase is due to the large amount of catalyst required.

The SCR system can utilize either aqueous or anhydrous ammonia as the reagent. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Today, catalyst formulations include single component, multi-component, or active phase with a support structure. Most catalyst formulations contain additional compounds or supports, providing thermal and structural stability or to increase surface area (EPA, 2002).

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include: reaction temperature range; residence time available in the optimum temperature range; degree of mixing between the injected

AT-A-GLANCE TABLE FOR POINT SOURCES

reagent and the combustion gases; uncontrolled NO_x concentration level; molar ratio of injected reagent to uncontrolled NO_x; ammonia slip; catalyst activity; catalyst selectivity; pressure drop across the catalyst; catalyst pitch; catalyst deactivation; and catalyst management (EPA, 2001).

References:

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Process Heaters," EPA,-453/R-93-034, Research Triangle Park, NC, September 1993.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Residential Natural Gas

Control Measure Name: Water Heater Replacement

Rule Name: Not Applicable

Pechan Measure Code: N10901

POD: 109

Application: This control would replace existing water heaters with new water heaters. New water heaters would be required to emit less than or equal to 40 ng NOx per Joule heat output.

This control applies to all natural gas burning water heaters classified under SCC 2104006000.

Affected SCC:

2104006000 Natural Gas, Total: All Combustor Types

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 7% from uncontrolled

Equipment Life: 13 years

Rule Effectiveness: 100%

Penetration: 23%

Cost Basis: In 1994, EPA conducted an analysis of the emission reductions and costs for a Federal Implementation Plan residential water heater rule for the Sacramento, California ozone nonattainment area (EPA, 1995). This analysis found that a rule based on an emission limit of 40 nanograms per joule (ng/j) of heat output for natural gas heaters with a heat input rating less than 75,000 Btu/hr would not result in an increase in the cost of natural gas water heaters. The cost-effectiveness of NOx reductions resulting from low-NOx residential water heaters is, therefore, zero dollar-per-ton of NOx removed.

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$0 per ton NOx reduced (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 1997

Additional Information:

EPA (1995) noted a life expectancy of both conventional and low-NOx units ranging from 10 to 15 years. Thus, rule penetration is based on an average water heater equipment life of 13 years (Pechan, 1996).

References:

EPA, 1995: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Costs for the California Federal Implementation Plans for Attainment of the Ozone National Ambient Air Quality Standard," Final Draft, February 1995.

AT-A-GLANCE TABLE FOR AREA SOURCES

Pechan, 1996: E.H. Pechan & Associates, "The Emission Reduction and Cost Analysis Model for NO_x (ECRAM-NO_x)," Revised Documentation, prepared for U.S. Environmental Protection Agency, Ozone Policy and Strategies Group, Research Triangle Park, NC, September 1996.

Pechan, 1997: E.H. Pechan & Associates, "Additional Control Measure Evaluation for the Integrated Implementation of the Ozone and Particulate Matter National Ambient Air Quality Standards, and Regional Haze Program," prepared for U.S. Environmental Protection Agency, July 1997.

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Residential Natural Gas

Control Measure Name: Water Heater + LNB Space Heaters

Rule Name: South Coast and Bay Area AQMD Limits

Pechan Measure Code: N10903

POD: 109

Application: The South Coast and Bay Area AQMDs set emission limits for water heaters and space heaters. This control is based on the installation of low-NOx space heaters and water heaters in commercial and institutional sources for the reduction of NOx emissions.

The control applies to natural gas burning sources classified under SCC 2104006000.

Affected SCC:

2104006000 Natural Gas, Total: All Combustor Types

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 7% from uncontrolled

Equipment Life: 20 years (space heaters)

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The 1997 South Coast AQMP estimates a cost savings for new commercial and residential water heaters meeting a low-NOx standard. The cost savings is based on capital costs associated with installation of energy efficient equipment existing demand-side management programs, energy savings, associated emission reductions, and the prevailing emission credit price (SCAQMD, 1996).

Costs for the space heaters are based on the low-NOx limits established for the South Coast and Bay Area Air Quality Management Districts for space heaters of 0.009 lbs NOx per million Btu. The cost effectiveness estimate for the low-NOx space heater regulation is \$1,600 per ton NOx (STAPPA/ALAPCO, 1994). For this analysis a 75% reduction in commercial space heater NOx emissions is assumed, based on a 20-year equipment life (Pechan, 1997).

The water heater savings and LNB space heater costs are combined to achieve an overall cost effectiveness of \$1,230 per ton NOx reduced.

Cost Effectiveness: The cost effectiveness is \$1,230 per ton NOx reduced (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 1997

Additional Information:

AT-A-GLANCE TABLE FOR AREA SOURCES

References:

Pechan, 1997: E.H. Pechan & Associates, Inc., "Additional Control Measure Evaluation for the Integrated Implementation of the Ozone and Particulate Matter National Ambient Air Quality Standards, and Regional Haze Program," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, July 1997.

SCAQMD, 1996: South Coast Air Quality Management District, "1997 Air Quality Management Plan, Appendix IV-A: Stationary and Mobile Source Control Measures," August 1996.

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Rich-Burn Stationary Reciprocating Internal Combustion Engines

Control Measure Name: Non-selective catalytic reduction

Rule Name: Not Applicable

Pechan Measure Code: N0215S, N02105

POD:

Application: NSCR is achieved by placing a catalyst in the exhaust stream of the engine. The exhaust passes over the catalyst, usually a noble metal (platinum, rhodium or palladium) which reduces the reactants to N₂, CO₂ and H₂O (NJDEP, 2003). Typical exhaust temperatures for effective removal of NO_x are 800-1200 degrees Fahrenheit. An oxidation catalyst using additional air can be installed downstream of the NSCR catalyst for additional CO and VOC control. This includes 4-cycle naturally aspirated engines and some 4-cycle turbocharged engines. Engines operating with NSCR require air/fuel control to maintain high reduction effectiveness.

Affected SCC:

20100102 (lean and rich burn)
20100202 (lean and rich burn)
20100702 (lean and rich burn)
20200102 (lean and rich burn)
20200104 (lean and rich burn)
20200202 (lean and rich burn)
20200204 (lean and rich burn)
20200253 (rich burn only)
20200301 (lean and rich burn)
20200401 (lean and rich burn) – large bore engine
20200402 (lean and rich burn) – large bore engine
20200403 (lean and rich burn) – large bore engine
20200501 (lean and rich burn)
20200902 (lean and rich burn)
20201001 (lean and rich burn)
20300101 (lean and rich burn)
20300201 (lean and rich burn)
20300204 (lean and rich burn)
20300301 (lean and rich burn)

Pollutant(s)	PM10	PM2.5	EC	OC	NO _x	VOC	SO ₂	NH ₃	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: •NO_x: 90% from uncontrolled (Pechan, 2000)
•CO: 90% from uncontrolled (NJDEP, 2003)
•VOC: 50% from uncontrolled (NJDEP, 2003)

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Control costs are estimated using an “ozone season” cost per ton. The ozone season runs from May 1 to September 30 (5 months). The total annualized cost is calculated using the operating cost incurred during the 5 month ozone season. An interest rate

AT-A-GLANCE TABLE FOR AREA SOURCES

of 7% was used to determine the capital recovery factor. Maintenance and overhead costs were estimated using recommended methods from the EPA Office of Air Quality Planning and Standards (OAQPS) Control Cost Manual. The maintenance cost is the maintenance labor rate times the number of expected additional maintenance hours per year (500). The overhead cost is 60 percent of the maintenance labor value. The fuel penalty is based on an estimated one percent decrease in natural gas use. Taxes, insurance, and administrative costs are estimated to be 4 percent of the capital cost. The compliance test cost is \$2,440, which is the same value that was estimated in an EPA alternative control techniques document (EPA, 1993).

Cost Effectiveness: The cost effectiveness is \$342 per ton of NO_x reduction (1990\$). The cost effectiveness is based on an annualized capital cost of \$16,778 and an annual operation and maintenance (O&M) cost of \$155,217 averaged over three rich-burn natural gas-fired RICE (2,000, 4,000, and 8,000 horsepower).

Comments:

Status: Demonstrated

Last Reviewed: 2004

Additional Information:

References:

EPA, 1993: U.S. Environmental Protection Agency, "Alternative Control Techniques Document – NO_x Emissions from Stationary Reciprocating Internal Combustion Engines", EPA-453/R-93-032, Office of Air Quality Planning and Standards, Research Triangle Park, NC, July 1993.

NJDEP, 2003: "State of the Art (SOTA) Manual for Reciprocating Internal Combustion Engines", State of New Jersey Department of Environmental Protection, Division of Air Quality, 2003.

Pechan, 2000: E.H. Pechan & Associates, Inc., "NO_x Emissions Control Costs for Stationary Reciprocating Internal Combustion Engines in the NO_x SIP Call States", Revised Final Report, August 11, 2000

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Rich-Burn Stationary Reciprocating Internal Combustion Engines

Control Measure Name: Non-selective catalytic reduction

Rule Name: Not Applicable

Pechan Measure Code: N2213

POD:

Application: NSCR is achieved by placing a catalyst in the exhaust stream of the engine. The exhaust passes over the catalyst, usually a noble metal (platinum, rhodium or palladium) which reduces the reactants to N₂, CO₂ and H₂O (NJDEP, 2003). Typical exhaust temperatures for effective removal of NO_x are 800-1200 degrees Fahrenheit. An oxidation catalyst using additional air can be installed downstream of the NSCR catalyst for additional CO and VOC control. This includes 4-cycle naturally aspirated engines and some 4-cycle turbocharged engines. Engines operating with NSCR require air/fuel control to maintain high reduction effectiveness.

Affected SCC:

20100102 (lean and rich burn)
20100202 (lean and rich burn)
20100702 (lean and rich burn)
20200102 (lean and rich burn)
20200104 (lean and rich burn)
20200202 (lean and rich burn)
20200204 (lean and rich burn)
20200253 (rich burn only)
20200301 (lean and rich burn)
20200401 (lean and rich burn) – large bore engine
20200402 (lean and rich burn) – large bore engine
20200403 (lean and rich burn) – large bore engine
20200501 (lean and rich burn)
20200902 (lean and rich burn)
20201001 (lean and rich burn)
20300101 (lean and rich burn)
20300201 (lean and rich burn)
20300204 (lean and rich burn)
20300301 (lean and rich burn)

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: •NO_x: 90% from uncontrolled (Pechan, 2000)
•CO: 90% from uncontrolled (NJDEP, 2003)
•VOC: 50% from uncontrolled (NJDEP, 2003)

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Control costs are estimated using an “ozone season” cost per ton. The ozone season runs from May 1 to September 30 (5 months). The total annualized cost is calculated using the operating cost incurred during the 5 month ozone season. An interest rate

AT-A-GLANCE TABLE FOR AREA SOURCES

of 7% was used to determine the capital recovery factor. Maintenance and overhead costs were estimated using recommended methods from the EPA Office of Air Quality Planning and Standards (OAQPS) Control Cost Manual. The maintenance cost is the maintenance labor rate times the number of expected additional maintenance hours per year (500). The overhead cost is 60 percent of the maintenance labor value. The fuel penalty is based on an estimated one percent decrease in natural gas use. Taxes, insurance, and administrative costs are estimated to be 4 percent of the capital cost. The compliance test cost is \$2,440, which is the same value that was estimated in an EPA alternative control techniques document (EPA, 1993).

Cost Effectiveness: The cost effectiveness is \$342 per ton of NO_x reduction (1990\$). The cost effectiveness is based on an annualized capital cost of \$16,778 and an annual operation and maintenance (O&M) cost of \$155,217 averaged over three rich-burn natural gas-fired RICE (2,000, 4,000, and 8,000 horsepower).

Comments:

Status: Demonstrated

Last Reviewed: 2004

Additional Information:

References:

EPA, 1993: U.S. Environmental Protection Agency, "Alternative Control Techniques Document – NO_x Emissions from Stationary Reciprocating Internal Combustion Engines", EPA-453/R-93-032, Office of Air Quality Planning and Standards, Research Triangle Park, NC, July 1993.

NJDEP, 2003: "State of the Art (SOTA) Manual for Reciprocating Internal Combustion Engines", State of New Jersey Department of Environmental Protection, Division of Air Quality, 2003.

Pechan, 2000: E.H. Pechan & Associates, Inc., "NO_x Emissions Control Costs for Stationary Reciprocating Internal Combustion Engines in the NO_x SIP Call States", Revised Final Report, August 11, 2000

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Rich-Burn Stationary Reciprocating Internal Combustion Engines (RICE)

Control Measure Name: Non-selective catalytic reduction (NSCR)

Rule Name: Not Applicable

Pechan Measure Code: N0465S, N04605

POD:

Application: NSCR is essentially the same as the catalytic reduction systems that are used in automobile applications (EIIP, 2000). NSCR is achieved by placing a catalyst in the exhaust stream of the engine. The exhaust passes over the catalyst, usually a noble metal (platinum, rhodium or palladium) which reduces the reactants to N₂, CO₂ and H₂O (NJDEP, 2003). Typical exhaust temperatures for effective removal of NO_x are 800-1200 degrees Fahrenheit. An oxidation catalyst using additional air can be installed downstream of the NSCR catalyst for additional CO and VOC control. This includes 4-cycle naturally aspirated engines and some 4-cycle turbocharged engines. Engines operating with NSCR require air/fuel control to maintain high reduction effectiveness. Extremely tight control of the air to fuel ratio operating range is accomplished with an electronic air to fuel ratio controller. NSCR is also referred to as three-way catalyst because it simultaneously reduces NO_x, CO, and HC to water, CO₂, and N₂.

Affected SCC:

2200301 Gasoline, Reciprocating
2200401 Industrial, Large Bore Engine, Diesel
2200402 Large Bore Engine, Dual Fuel (Oil/Gas)
2200403 Large Bore Engine, Cogeneration: Dual Fuel
2200902 Kerosene/Naphtha (Jet Fuel), Reciprocating
2201001 Liquefied Petroleum Gas (LPG), Propane: Reciprocating
2300301 Gasoline, Reciprocating
2301001 Liquefied Petroleum Gas (LPG), Propane: Reciprocating

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*	√			√	

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: NO_x: 90% from uncontrolled (Pechan, 2000)

CO: 90% from uncontrolled (NJDEP, 2003)

VOC: 50% from uncontrolled (NJDEP, 2003)

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Control costs are estimated using an "ozone season" cost per ton. The ozone season runs from May 1 to September 30 (5 months). The total annualized cost is calculated using the operating cost incurred during the 5 month ozone season. An interest rate of 7% was used to determine the capital recovery factor. Maintenance and overhead costs were estimated using recommended methods from the EPA Office of Air Quality Planning and Standards (OAQPS) Control Cost Manual. The maintenance cost is the maintenance labor rate times the number of expected additional maintenance hours per year (500). The overhead cost is 60 percent of the maintenance labor value. The fuel penalty is based on an estimated one percent

AT-A-GLANCE TABLE FOR POINT SOURCES

decrease in natural gas use. Taxes, insurance, and administrative costs are estimated to be 4 percent of the capital cost. The compliance test cost is \$2,440, which is the same value that was estimated in an EPA alternative control techniques document (EPA, 1993).

Cost Effectiveness: The cost effectiveness is \$342 per ton of NO_x reduction (1990\$). The cost effectiveness is based on an annualized capital cost of \$16,778 and an annual operation and maintenance (O&M) cost of \$155,217 averaged over three rich-burn natural gas-fired RICE (2,000, 4,000, and 8,000 horsepower).

Comments:

Status: Demonstrated

Last Reviewed: 2004

Additional Information:

References:

EIIP, 2000: "How to Incorporate the Effects of Air Pollution Control Device Efficiencies and Malfunctions into Emission Inventory Estimates", Volume II, Chapter 12, Emission Inventory Improvement Program, July 2000.

EPA, 1993: U.S. Environmental Protection Agency, "Alternative Control Techniques Document – NO_x Emissions from Stationary Reciprocating Internal Combustion Engines", EPA-453/R-93-032, Office of Air Quality Planning and Standards, Research Triangle Park, NC, July 1993.

NJDEP, 2003: "State of the Art (SOTA) Manual for Reciprocating Internal Combustion Engines", State of New Jersey Department of Environmental Protection, Division of Air Quality, 2003.

Pechan, 2000: E.H. Pechan & Associates, Inc., "NO_x Emissions Control Costs for Stationary Reciprocating Internal Combustion Engines in the NO_x SIP Call States", Revised Final Report, August 11, 2000.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Sand/Gravel; Dryer - Small Sources

Control Measure Name: Low NOx Burner + Flue Gas Recirculation

Rule Name: Not Applicable

Pechan Measure Code: N0772S, N07702

POD: 77

Application: This control is the use of low NOx burner (LNB) technology and flue gas recirculation (FGR) to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another.

This control is applicable to small (<1 ton NOx per OSD) sand and gravel drying processes with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

30502508 Construction Sand & Gravel, Dryer (See 3-05-027-20 thru -24 Industrial Sand Dryers)

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 55% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NOx emissions (Pechan, 1998).

Small source = less than 1 ton NOx emissions per ozone season day

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). The basis of the costs are model plant data for mechanical draft heaters firing natural gas and oil contained in the Alternative Control Techniques (ACT) document (EPA, 1993). From this analysis, default cost per ton values are assigned along with a capital to annual costs ratio of 6.9. An equipment life of 15 years is assumed (EPA, 1993).

Cost Effectiveness: The default cost effectiveness values are \$3,190 per ton NOx reduced from uncontrolled and \$1,430 per ton NOx reduced from RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNBs create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNBs create a lean combustion zone that is relatively cool due to the presence of

AT-A-GLANCE TABLE FOR POINT SOURCES

excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

References:

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Process Heaters," EPA,-453/R-93-034, Research Triangle Park, NC, September 1993.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Secondary Aluminum Production; Smelting Furnaces

Control Measure Name: Low NOx Burner

Rule Name: Not Applicable

Pechan Measure Code: N0701S, N07001

POD: 70

Application: This control is the use of low NOx burner (LNB) technology to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another.

This control is applicable to secondary aluminum production operations with smelting furnaces (SCC 30400103) and uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

30400103 Secondary Metal Production, Aluminum, Smelting Furnace/Reverberatory

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 50% from uncontrolled

Equipment Life: 10 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The basis of the costs are model plant data contained in the Alternative Control Techniques (ACT) (EPA, 1994). Capital, and annual cost information was obtained from control-specific cost data. Some O&M costs were included. Missing O&M costs were back calculated from annual costs (Pechan, 1998). From these determinations, an average cost per ton values was assigned along with a capital cost to annual cost ratio of 7.0. A discount rate of 7% was assumed for all sources. The equipment life is 10 years.

Cost Effectiveness: The default cost effectiveness value used in AirControlNET is \$570 per ton NOx reduced from both uncontrolled and RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 1998

Additional Information:

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNBs create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNBs create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

AT-A-GLANCE TABLE FOR POINT SOURCES

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Iron and Steel Mills," EPA-453/R-94-065, Research Triangle Park, NC, September 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Solid Waste Disposal; Government; Other

Control Measure Name: Selective Non-Catalytic Reduction (SNCR)

Rule Name: Not Applicable

Pechan Measure Code: N0891S, N08901

POD: 89

Application: This control is the reduction of NO_x emission through selective non-catalytic reduction add-on controls. SNCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NO_x) into molecular nitrogen (N₂) and water vapor (H₂O).

This control applies to solid waste disposal operations (classified under SCC 50100506) with uncontrolled NO_x emissions greater than 10 tons per year.

Affected SCC:

50100506 Other Incineration, Sludge

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 45% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NO_x emission levels (Pechan, 1998).

Small source = emission levels less than 1 ton per ozone season day

Large source = emission levels greater than 1 ton per ozone season day

Costs for stationary source NO_x control are based on an analysis of EPA's NO_x State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned for small sources. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 20 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than 70% (Pechan, 2001).

Cost Effectiveness: The cost effectiveness (for both small and large sources) used in AirControlNET for both reductions from baseline and reductions from RACT is \$1,130 per ton NO_x reduced (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

SNCR is the reduction of NO_x in flue gas to N₂ and water vapor. This reduction is done with a nitrogen based reducing reagent, such as ammonia or urea. The reagent can react with a number of flue gas components. However, the NO_x reduction reaction is favored for a specific temperature range and in the presence of oxygen (EPA, 2002).

Both ammonia and urea are used as reagents. The cost of the reagent represents a large part of the annual costs of an SNCR system. Ammonia is generally less expensive than urea. However, the choice of reagent is also based on physical properties and operational considerations (EPA, 2002).

Ammonia can be utilized in either aqueous or anhydrous form. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Urea based systems have several advantages, including several safety aspects. Urea is a nontoxic, less volatile liquid that can be stored and handled more safely than ammonia. Urea solution droplets can penetrate farther into the flue gas when injected into the boiler, enhancing mixing (EPA, 2002). Because of these advantages, urea is more commonly used than ammonia in large boiler applications.

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include:

Reaction temperature range;
Residence time available in the optimum temperature range;
Degree of mixing between the injected reagent and the combustion gases
Uncontrolled NO_x concentration level;
Molar ratio of injected reagent to uncontrolled NO_x ; and
Ammonia slip.

References:

EPA, 1994: U.S. Environmental Protection Agency, Radian Corporation, "Alternative Control Techniques Document-- NO_x Emissions from Municipal Waste Combustion," EPA-600/R-94-208, Research Triangle Park, NC, December 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Space Heaters - Distillate Oil - Small Sources

Control Measure Name: Low NOx Burner

Rule Name: Not Applicable

Pechan Measure Code: N0541S, N0540I

POD: 54

Application: This control is the use of low NOx burner (LNB) technology to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another.

This control is applicable to small (<1 ton NOx per OSD) distillate oil-fired space heaters with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

10500105 Space Heaters, Industrial, Distillate Oil

10500205 Commercial/Institutional, Distillate Oil

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 50% from uncontrolled

Equipment Life: 10 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NOx emissions (Pechan, 1998).

Small source = less than 1 ton NOx emissions per ozone season day

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). The basis of the costs are model plant data for mechanical draft heaters firing natural gas and oil contained in the Alternative Control Techniques (ACT) document (EPA, 1994). From this analysis, default cost per ton values are assigned along with a capital to annual costs ratio of 5.5. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 10 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 70% (Pechan, 2001).

Cost Effectiveness: The default cost effectiveness value used in AirControlINET is \$1,180 per ton NOx reduced from both uncontrolled and RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNBs create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNBs create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Industrial/Commercial/Institutional (ICI) Boilers," EPA,-453/R-94-022, Research Triangle Park, NC, June 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Space Heaters - Distillate Oil - Small Sources

Control Measure Name: Low NOx Burner + Flue Gas Recirculation

Rule Name: Not Applicable

Pechan Measure Code: N0542S, N05402

POD: 54

Application: This control is the use of low NOx burner (LNB) technology and flue gas recirculation (FGR) to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another.

This control is applicable to small (<1 ton per OSD) residual oil-fired process heaters with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

10500105 Space Heaters, Industrial, Distillate Oil

10500205 Commercial/Institutional, Distillate Oil

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 60% from uncontrolled

Equipment Life: 10 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by power output (Pechan, 1998).

Small source = less than 1 ton NOx per ozone season day

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). The basis of the costs are model plant data in the Alternative Control Techniques (ACT) document (EPA, 1994). From this analysis, default cost per ton values are assigned along with a capital to annual costs ratio of 5.9. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 10 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 70% (Pechan, 2001).

Cost Effectiveness: The default cost effectiveness values are \$2,490 per ton NOx reduced from uncontrolled and \$1,090 per ton NOx reduced from RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNBs create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNBs create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Industrial/Commercial/Institutional (ICI) Boilers," EPA,-453/R-94-022, Research Triangle Park, NC, June 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Space Heaters - Distillate Oil - Small Sources

Control Measure Name: Selective Catalytic Reduction (SCR)

Rule Name: Not Applicable

Pechan Measure Code: N0543S, N05403

POD: 54

Application: This control is the selective catalytic reduction of NOx through add-on controls. SCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NOx) into molecular nitrogen (N₂) and water vapor (H₂O). The SCR utilizes a catalyst to increase the NOx removal efficiency, which allows the process to occur at lower temperatures.

Applies to small (<1 ton NOx per OSD) distillate oil-fired space heaters with NOx emissions greater than 10 tons per year.

Affected SCC:

10500105 Space Heaters, Industrial, Distillate Oil
10500205 Commercial/Institutional, Distillate Oil

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 80% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NOx emission levels (Pechan, 1998).

Small source = emission levels less than 1 ton per ozone season day

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 20 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 70% (Pechan, 2001).

Cost Effectiveness: The cost effectiveness values used in AirControlNET are \$2,780 per ton NOx reduced from uncontrolled and \$3,570 per ton NOx reduced from RACT baseline (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

Selective Catalytic Reduction (SCR) has been widely applied to stationary source, fossil fuel-fired, combustion units for emission control since the early 1970s. SCR is typically implemented on units requiring a higher level of NO_x control than achievable by SNCR or other combustion controls (EPA, 2002).

Like SNCR, SCR is based on the chemical reduction of the NO_x molecule. The primary difference between SNCR and SCR is that SCR uses a metal-based catalyst to increase the rate of reaction (EPA, 2002). A nitrogen based reducing reagent, such as ammonia or urea, is injected into the flue gas. The reagent reacts selectively with the flue gas NO_x within a specific temperature range and in the presence of the catalyst and oxygen to reduce the NO_x.

The use of a catalyst results in two advantages of the SCR process over SNCR, the higher NO_x reduction efficiency and the lower and broader temperature ranges. However, the decrease in reaction temperature and increase in efficiency is accompanied by a significant increase in capital and operating costs (EPA, 2002). The cost increase is due to the large amount of catalyst required.

The SCR system can utilize either aqueous or anhydrous ammonia as the reagent. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Today, catalyst formulations include single component, multi-component, or active phase with a support structure. Most catalyst formulations contain additional compounds or supports, providing thermal and structural stability or to increase surface area (EPA, 2002).

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include: reaction temperature range; residence time available in the optimum temperature range; degree of mixing between the injected reagent and the combustion gases; uncontrolled NO_x concentration level; molar ratio of injected reagent to uncontrolled NO_x; ammonia slip; catalyst activity; catalyst selectivity; pressure drop across the catalyst; catalyst pitch; catalyst deactivation; and catalyst management (EPA, 2001).

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Industrial/Commercial/Institutional (ICI) Boilers," EPA-453/R-94-022, Research Triangle Park, NC, June 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Space Heaters - Distillate Oil - Small Sources

Control Measure Name: Selective Non-Catalytic Reduction (SNCR)

Rule Name: Not Applicable

Pechan Measure Code: N0544S, N05404

POD: 54

Application: This control is the reduction of NO_x emission through selective non-catalytic reduction add-on controls. SNCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NO_x) into molecular nitrogen (N₂) and water vapor (H₂O).

This control applies to small (<1 ton NO_x emissions per OSD) distillate oil-fired space heaters with uncontrolled NO_x emissions greater than 10 tons per year, classified under SCCs 10500105 and 10500205.

Affected SCC:

10500105 Space Heaters, Industrial, Distillate Oil
10500205 Commercial/Institutional, Distillate Oil

Pollutant(s)	PM10	PM2.5	EC	OC	NO _x	VOC	SO ₂	NH ₃	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 50% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NO_x emission levels (Pechan, 1998).

Small source = emission levels less than 1 ton per ozone season day

Costs for stationary source NO_x control are based on an analysis of EPA's NO_x State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned for small sources. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 20 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 70% (Pechan, 2001).

Cost Effectiveness: The cost effectiveness values used in AirControlNET are \$4,640 per ton NO_x reduced from uncontrolled and \$3,470 per ton NO_x reduced from RACT baseline (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

SNCR is the reduction of NO_x in flue gas to N₂ and water vapor. This reduction is done with a nitrogen based reducing reagent, such as ammonia or urea. The reagent can react with a number of flue gas components. However, the NO_x reduction reaction is favored for a specific temperature range and in the presence of oxygen (EPA, 2002).

Both ammonia and urea are used as reagents. The cost of the reagent represents a large part of the annual costs of an SNCR system. Ammonia is generally less expensive than urea. However, the choice of reagent is also based on physical properties and operational considerations (EPA, 2002).

Ammonia can be utilized in either aqueous or anhydrous form. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Urea based systems have several advantages, including several safety aspects. Urea is a nontoxic, less volatile liquid that can be stored and handled more safely than ammonia. Urea solution droplets can penetrate farther into the flue gas when injected into the boiler, enhancing mixing (EPA, 2002). Because of these advantages, urea is more commonly used than ammonia in large boiler applications.

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include:

Reaction temperature range;
Residence time available in the optimum temperature range;
Degree of mixing between the injected reagent and the combustion gases
Uncontrolled NO_x concentration level;
Molar ratio of injected reagent to uncontrolled NO_x ; and
Ammonia slip.

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Industrial/Commercial/Institutional (ICI) Boilers," EPA-453/R-94-022, Research Triangle Park, NC, June 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Space Heaters - Natural Gas - Small Sources

Control Measure Name: Low NOx Burner

Rule Name: Not Applicable

Pechan Measure Code: N0551S, N05501

POD: 55

Application: This control is the use of low NOx burner (LNB) technology to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another.

This control is applicable to small (<1 ton NOx per OSD) natural gas-fired space heaters with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

10500106 Space Heaters, Industrial, Natural Gas

10500206 Commercial/Institutional, Natural Gas

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 50% from uncontrolled

Equipment Life: 10 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NOx emissions (Pechan, 1998).

Small source = less than 1 ton NOx emissions per ozone season day

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). The basis of the costs are model plant data for mechanical draft heaters firing natural gas and oil contained in the Alternative Control Techniques (ACT) document (EPA, 1994). From this analysis, default cost per ton values are assigned along with a capital to annual costs ratio of 5.5. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 10 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 70% (Pechan, 2001).

Cost Effectiveness: The default cost effectiveness value used in AirControlINET is \$820 per ton NOx reduced from both uncontrolled and RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNBs create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNBs create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Industrial/Commercial/Institutional (ICI) Boilers," EPA,-453/R-94-022, Research Triangle Park, NC, June 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Space Heaters - Natural Gas - Small Sources

Control Measure Name: Low NOx Burner + Flue Gas Recirculation

Rule Name: Not Applicable

Pechan Measure Code: N0552S, N05502

POD: 55

Application: This control is the use of low NOx burner (LNB) technology and flue gas recirculation (FGR) to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another.

This control is applicable to small (<1 ton per OSD) LPG-fired process heaters with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

10500106 Space Heaters, Industrial, Natural Gas

10500206 Commercial/Institutional, Natural Gas

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 60% from uncontrolled

Equipment Life: 10 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by power output (Pechan, 1998).

Small source = less than 1 ton NOx per ozone season day

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). The basis of the costs are model plant data in the Alternative Control Techniques (ACT) document (EPA, 1994). From this analysis, default cost per ton values are assigned along with a capital to annual costs ratio of 5.9. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 10 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 70% (Pechan, 2001).

Cost Effectiveness: The default cost effectiveness values are \$2,560 per ton NOx reduced from uncontrolled and \$2,470 per ton NOx reduced from RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNBs create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNBs create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Industrial/Commercial/Institutional (ICI) Boilers," EPA,-453/R-94-022, Research Triangle Park, NC, June 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Space Heaters - Natural Gas - Small Sources

Control Measure Name: Oxygen Trim + Water Injection

Rule Name: Not Applicable

Pechan Measure Code: N0553S, N05503

POD: 55

Application: This control is the use of OT + WI to reduce NOx emissions.

This control applies to small (<1 ton NOx per OSD) natural gas-fired space heaters with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

10500106 Space Heaters, Industrial, Natural Gas

10500206 Commercial/Institutional, Natural Gas

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 65% from uncontrolled

Equipment Life: 10 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 70% (Pechan, 2001).

Cost Effectiveness: The default cost effectiveness value is \$680 per ton NOx reduced from both uncontrolled and RACT baselines (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

Water is injected into the gas turbine, reducing the temperatures in the NOx-forming regions. The water can be injected into the fuel, the combustion air or directly into the combustion chamber (ERG, 2000).

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Industrial/Commercial/Institutional (ICI) Boilers," EPA-453/R-94-022, Research Triangle Park, NC, June 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

ERG, 2000: Eastern Research Group, Inc., "How to Incorporate the Effects of Air Pollution Control Device Efficiencies and Malfunctions into Emission Inventory Estimates," prepared for Emission

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Inventory Improvement Program, Point Sources Committee, July 2000.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Space Heaters - Natural Gas - Small Sources

Control Measure Name: Selective Catalytic Reduction (SCR)

Rule Name: Not Applicable

Pechan Measure Code: N0554S, N05504

POD: 55

Application: This control is the selective catalytic reduction of NOx through add-on controls. SCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NOx) into molecular nitrogen (N₂) and water vapor (H₂O). The SCR utilizes a catalyst to increase the NOx removal efficiency, which allows the process to occur at lower temperatures.

Applies to small (<1 ton NOx per OSD) natural gas fired space heaters with NOx emissions greater than 10 tons per year.

Affected SCC:

10500106 Space Heaters, Industrial, Natural Gas

10500206 Commercial/Institutional, Natural Gas

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 80% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NOx emission levels (Pechan, 1998).

Small source = emission levels less than 1 ton per ozone season day

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 20 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 70% (Pechan, 2001).

Cost Effectiveness: The cost effectiveness values used in AirControlNET are \$2,230 per ton NOx reduced from uncontrolled and \$2,860 per ton NOx reduced from RACT baseline (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

Selective Catalytic Reduction (SCR) has been widely applied to stationary source, fossil fuel-fired, combustion units for emission control since the early 1970s. SCR is typically implemented on units requiring a higher level of NO_x control than achievable by SNCR or other combustion controls (EPA, 2002).

Like SNCR, SCR is based on the chemical reduction of the NO_x molecule. The primary difference between SNCR and SCR is that SCR uses a metal-based catalyst to increase the rate of reaction (EPA, 2002). A nitrogen based reducing reagent, such as ammonia or urea, is injected into the flue gas. The reagent reacts selectively with the flue gas NO_x within a specific temperature range and in the presence of the catalyst and oxygen to reduce the NO_x.

The use of a catalyst results in two advantages of the SCR process over SNCR, the higher NO_x reduction efficiency and the lower and broader temperature ranges. However, the decrease in reaction temperature and increase in efficiency is accompanied by a significant increase in capital and operating costs (EPA, 2002). The cost increase is due to the large amount of catalyst required.

The SCR system can utilize either aqueous or anhydrous ammonia as the reagent. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Today, catalyst formulations include single component, multi-component, or active phase with a support structure. Most catalyst formulations contain additional compounds or supports, providing thermal and structural stability or to increase surface area (EPA, 2002).

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include: reaction temperature range; residence time available in the optimum temperature range; degree of mixing between the injected reagent and the combustion gases; uncontrolled NO_x concentration level; molar ratio of injected reagent to uncontrolled NO_x; ammonia slip; catalyst activity; catalyst selectivity; pressure drop across the catalyst; catalyst pitch; catalyst deactivation; and catalyst management (EPA, 2001).

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Industrial/Commercial/Institutional (ICI) Boilers," EPA-453/R-94-022, Research Triangle Park, NC, June 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Space Heaters - Natural Gas - Small Sources

Control Measure Name: Selective Non-Catalytic Reduction (SNCR)

Rule Name: Not Applicable

Pechan Measure Code: N0555S, N0550S

POD: 55

Application: This control is the reduction of NO_x emission through selective non-catalytic reduction add-on controls. SNCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NO_x) into molecular nitrogen (N₂) and water vapor (H₂O).

This control applies to small (<1 ton NO_x emissions per OSD) natural gas fired space heaters with uncontrolled NO_x emissions greater than 10 tons per year, classified under SCCs 10500106 and 10500206.

Affected SCC:

10500106 Space Heaters, Industrial, Natural Gas

10500206 Commercial/Institutional, Natural Gas

Pollutant(s)	PM10	PM2.5	EC	OC	NO _x	VOC	SO ₂	NH ₃	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 50% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NO_x emission levels (Pechan, 1998).

Small source = emission levels less than 1 ton per ozone season day

Costs for stationary source NO_x control are based on an analysis of EPA's NO_x State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned for small sources. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 20 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 70% (Pechan, 2001).

Cost Effectiveness: The cost effectiveness values used in AirControlNET are \$3,870 per ton NO_x reduced from uncontrolled and \$ 2,900 per ton NO_x reduced from RACT baseline (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

SNCR is the reduction of NO_x in flue gas to N₂ and water vapor. This reduction is done with a nitrogen based reducing reagent, such as ammonia or urea. The reagent can react with a number of flue gas components. However, the NO_x reduction reaction is favored for a specific temperature range and in the presence of oxygen (EPA, 2002).

Both ammonia and urea are used as reagents. The cost of the reagent represents a large part of the annual costs of an SNCR system. Ammonia is generally less expensive than urea. However, the choice of reagent is also based on physical properties and operational considerations (EPA, 2002).

Ammonia can be utilized in either aqueous or anhydrous form. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Urea based systems have several advantages, including several safety aspects. Urea is a nontoxic, less volatile liquid that can be stored and handled more safely than ammonia. Urea solution droplets can penetrate farther into the flue gas when injected into the boiler, enhancing mixing (EPA, 2002). Because of these advantages, urea is more commonly used than ammonia in large boiler applications.

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include:

Reaction temperature range;
Residence time available in the optimum temperature range;
Degree of mixing between the injected reagent and the combustion gases
Uncontrolled NO_x concentration level;
Molar ratio of injected reagent to uncontrolled NO_x ; and
Ammonia slip.

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Industrial/Commercial/Institutional (ICI) Boilers," EPA,-453/R-94-022, Research Triangle Park, NC, June 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Starch Manufacturing; Combined Operation - Small Sources

Control Measure Name: Low NOx Burner + Flue Gas Recirculation

Rule Name: Not Applicable

Pechan Measure Code: N0642S, N06402

POD: 64

Application: This control is the use of low NOx burner (LNB) technology and flue gas recirculation (FGR) to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another.

This control is applicable to small (<1 ton per OSD) starch manufacturing with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

30201401 Starch Manufacturing, Combined Operations

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 55% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by power output (Pechan, 1998).

Small source = less than 1 ton NOx per ozone season day

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). The basis of the costs are model plant data in the Alternative Control Techniques (ACT) document (EPA, 1994). From this analysis, default cost per ton values are assigned along with a capital to annual costs ratio of 6.9. An equipment life of 15 years was uncontrolled (EPA, 1994).

Cost Effectiveness: The default cost effectiveness values are \$3,190 per ton NOx reduced from uncontrolled and \$1,430 per ton NOx reduced from RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

The NOx source is generally a natural gas-fired dryer. Therefore, applicable control technologies are assumed to be LNB with FGR.

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-

AT-A-GLANCE TABLE FOR POINT SOURCES

air LNBs create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNBs create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

References:

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Process Heaters," EPA,-453/R-93-034, Research Triangle Park, NC, September 1993.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Steel Foundries; Heat Treating

Control Measure Name: Low NOx Burner

Rule Name: Not Applicable

Pechan Measure Code: N0711S, N07101

POD: 71

Application: This control is the use of low NOx burner (LNB) technology to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another.

This control is applicable to heat treating operations at steel foundries (SCC 30400704) with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

30400704 Steel Foundries, Heat Treating Furnace

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 50% from uncontrolled

Equipment Life: 10 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). The basis of the costs are model plant data for mechanical draft heaters firing natural gas and oil contained in the Alternative Control Techniques (ACT) document (EPA, 1994). From this analysis, default cost per ton values are assigned along with a capital to annual costs ratio of 7.0. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 10 years (EPA, 1994).

Cost Effectiveness: The default cost effectiveness value used in AirControlNET is \$570 per ton NOx reduced from both uncontrolled and RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 1998

Additional Information:

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNBs create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNBs create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

AT-A-GLANCE TABLE FOR POINT SOURCES

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Iron and Steel Mills," EPA-453/R-94-065, Research Triangle Park, NC, September 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Steel Production; Soaking Pits

Control Measure Name: Low NOx Burner + Flue Gas Recirculation

Rule Name: Not Applicable

Pechan Measure Code: N0682S, N06802

POD: 68

Application: This control is the use of low NOx burner (LNB) technology and flue gas recirculation (FGR) to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another.

This control is applicable to soaking pits at steel production operations with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

30300911 Steel Manufacturing (See 3-03-015), Soaking Pits

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 60% from uncontrolled

Equipment Life: 10 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). The basis of the costs are model plant data in the Alternative Control Techniques (ACT) document (EPA, 1994). From this analysis, default cost per ton values are assigned along with a capital to annual costs ratio of 7.0. An equipment life of 10 years was uncontrolled (EPA, 1994).

Cost Effectiveness: The default cost effectiveness values are \$750 per ton NOx reduced from uncontrolled and \$250 per ton NOx reduced from RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

Soaking pits are a combustion source which can fire natural gas, oil or coal. Emissions of NOx are similar to boilers emissions.

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNBs create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNBs create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

AT-A-GLANCE TABLE FOR POINT SOURCES

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Iron and Steel Mills," EPA-453/R-94-065, Research Triangle Park, NC, September 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Sulfate Pulping - Recovery Furnaces - Small Sources

Control Measure Name: Low NOx Burner

Rule Name: Not Applicable

Pechan Measure Code: N0611S, N0610I

POD: 61

Application: This control is the use of low NOx burner (LNB) technology to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another.

This control is applicable to small (<1 ton NOx per OSD) recovery furnaces at sulfate pulping operations with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

30700104 Pulp, Paper & Wood, Sulfate Pulping, Recovery Furnace/Direct Contact Evaporator

30700110 Sulfate (Kraft) Pulping, Recovery Furnace/Indirect Contact Evaporator

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 50% from uncontrolled

Equipment Life: 10 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NOx emissions (Pechan, 1998).

Small source = less than 1 ton NOx emissions per ozone season day

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). The basis of the costs are model plant data for mechanical draft heaters firing natural gas and oil contained in the Alternative Control Techniques (ACT) document (EPA, 1994). From this analysis, default cost per ton values are assigned along with a capital to annual costs ratio of 5.5. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 10 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 70% (Pechan, 2001).

Cost Effectiveness: The default cost effectiveness value used in AirControlINET is \$820 per ton NOx reduced from both uncontrolled and RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

Cost equations for NO_x control of sulfate pulping recovery furnaces are based on an analysis of EPA's NO_x State Implementation Plan (SIP) Call (Pechan, 1998) and STAPPA/ALAPCO's Controlling Nitrogen Oxides Under the Clean Air Act: A Menu of Options. Applicable control technologies and costs are assumed to be similar to ICI boilers firing natural gas.

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Industrial/Commercial/Institutional (ICI) Boilers," EPA,-453/R-94-022, Research Triangle Park, NC, June 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Sulfate Pulping - Recovery Furnaces - Small Sources

Control Measure Name: Low NOx Burner + Flue Gas Recirculation

Rule Name: Not Applicable

Pechan Measure Code: N0612S, N06102

POD: 61

Application: This control is the use of low NOx burner (LNB) technology and flue gas recirculation (FGR) to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another.

This control is applicable to small (<1 ton per OSD) residual oil-fired process heaters with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

30700104 Pulp, Paper & Wood, Sulfate Pulping, Recovery Furnace/Direct Contact Evaporator

30700110 Sulfate (Kraft) Pulping, Recovery Furnace/Indirect Contact Evaporator

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 60% from uncontrolled

Equipment Life: 10 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by power output (Pechan, 1998).

Small source = less than 1 ton NOx per ozone season day

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). The basis of the costs are model plant data in the Alternative Control Techniques (ACT) document (EPA, 1994). From this analysis, default cost per ton values are assigned along with a capital to annual costs ratio of 5.9. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 10 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 70% (Pechan, 2001).

Cost Effectiveness: The default cost effectiveness values are \$2,560 per ton NOx reduced from uncontrolled and \$2,470 per ton NOx reduced from RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNBs create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNBs create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Industrial/Commercial/Institutional (ICI) Boilers," EPA,-453/R-94-022, Research Triangle Park, NC, June 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Sulfate Pulping - Recovery Furnaces - Small Sources

Control Measure Name: Oxygen Trim + Water Injection

Rule Name: Not Applicable

Pechan Measure Code: N0613S, N06103

POD: 61

Application: This control is the use of OT + WI to reduce NO_x emissions.

This control applies to small (<1 ton NO_x per OSD) recovery furnaces involved in sulfate pulping operations with uncontrolled NO_x emissions greater than 10 tons per year.

Affected SCC:

30700104 Pulp, Paper & Wood, Sulfate Pulping, Recovery Furnace/Direct Contact Evaporator

30700110 Sulfate (Kraft) Pulping, Recovery Furnace/Indirect Contact Evaporator

Pollutant(s)	PM10	PM2.5	EC	OC	NO _x	VOC	SO ₂	NH ₃	CO	Hg
					√/*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 65% from uncontrolled

Equipment Life: 10 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by power output (Pechan, 1998).

Small source = less than 1 ton NO_x per ozone season day

Costs for stationary source NO_x control are based on an analysis of EPA's NO_x State Implementation Plan (SIP) Call (Pechan, 1998). The basis of the costs are model plant data in the Alternative Control Techniques (ACT) document (EPA, 1994). From this analysis, default cost per ton values are assigned along with a capital to annual costs ratio of 2.9. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 10 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 70% (Pechan, 2001).

Cost Effectiveness: The default cost effectiveness value is \$680 per ton NO_x reduced from both uncontrolled and RACT baselines (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

Water is injected into the gas turbine, reducing the temperatures in the NO_x-forming regions. The water can be injected into the fuel, the combustion air or directly into the combustion chamber (ERG, 2000).

AT-A-GLANCE TABLE FOR POINT SOURCES

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NOx Emissions from Industrial/Commercial/Institutional (ICI) Boilers," EPA-453/R-94-022, Research Triangle Park, NC, June 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

ERG, 2000: Eastern Research Group, Inc., "How to Incorporate the Effects of Air Pollution Control Device Efficiencies and Malfunctions into Emission Inventory Estimates," prepared for Emission Inventory Improvement Program, Point Sources Committee, July 2000.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Sulfate Pulping - Recovery Furnaces - Small Sources

Control Measure Name: Selective Catalytic Reduction (SCR)

Rule Name: Not Applicable

Pechan Measure Code: N0614S, N06104

POD: 61

Application: This control is the selective catalytic reduction of NOx through add-on controls. SCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NOx) into molecular nitrogen (N2) and water vapor (H2O). The SCR utilizes a catalyst to increase the NOx removal efficiency, which allows the process to occur at lower temperatures.

Applies to small (<1 ton NOx per OSD) recovery furnaces in sulfate pulping operations with NOx emissions greater than 10 tons per year.

Affected SCC:

30700104 Pulp, Paper & Wood, Sulfate Pulping, Recovery Furnace/Direct Contact Evaporator
30700110 Sulfate (Kraft) Pulping, Recovery Furnace/Indirect Contact Evaporator

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 80% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NOx emission levels (Pechan, 1998).

Small source = emission levels less than 1 ton per ozone season day

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 20 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 70% (Pechan, 2001).

Cost Effectiveness: The cost effectiveness values used in AirControlNET are \$2,230 per ton NOx reduced from uncontrolled and \$2,860 per ton NOx reduced from RACT baseline (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

Selective Catalytic Reduction (SCR) has been widely applied to stationary source, fossil fuel-fired, combustion units for emission control since the early 1970s. SCR is typically implemented on units requiring a higher level of NO_x control than achievable by SNCR or other combustion controls (EPA, 2002).

Like SNCR, SCR is based on the chemical reduction of the NO_x molecule. The primary difference between SNCR and SCR is that SCR uses a metal-based catalyst to increase the rate of reaction (EPA, 2002). A nitrogen based reducing reagent, such as ammonia or urea, is injected into the flue gas. The reagent reacts selectively with the flue gas NO_x within a specific temperature range and in the presence of the catalyst and oxygen to reduce the NO_x.

The use of a catalyst results in two advantages of the SCR process over SNCR, the higher NO_x reduction efficiency and the lower and broader temperature ranges. However, the decrease in reaction temperature and increase in efficiency is accompanied by a significant increase in capital and operating costs (EPA, 2002). The cost increase is due to the large amount of catalyst required.

The SCR system can utilize either aqueous or anhydrous ammonia as the reagent. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Today, catalyst formulations include single component, multi-component, or active phase with a support structure. Most catalyst formulations contain additional compounds or supports, providing thermal and structural stability or to increase surface area (EPA, 2002).

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include: reaction temperature range; residence time available in the optimum temperature range; degree of mixing between the injected reagent and the combustion gases; uncontrolled NO_x concentration level; molar ratio of injected reagent to uncontrolled NO_x; ammonia slip; catalyst activity; catalyst selectivity; pressure drop across the catalyst; catalyst pitch; catalyst deactivation; and catalyst management (EPA, 2001).

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Industrial/Commercial/Institutional (ICI) Boilers," EPA-453/R-94-022, Research Triangle Park, NC, June 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Sulfate Pulping - Recovery Furnaces - Small Sources

Control Measure Name: Selective Non-Catalytic Reduction (SNCR)

Rule Name: Not Applicable

Pechan Measure Code: N0615S, N06105

POD: 61

Application: This control is the reduction of NO_x emission through selective non-catalytic reduction add-on controls. SNCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NO_x) into molecular nitrogen (N₂) and water vapor (H₂O).

This control applies to small (<1 ton NO_x emissions per OSD) sulfate pulping operations with recovery furnaces and uncontrolled NO_x emissions greater than 10 tons per year.

Affected SCC:

30700104 Pulp, Paper & Wood, Sulfate Pulping, Recovery Furnace/Direct Contact Evaporator
30700110 Sulfate (Kraft) Pulping, Recovery Furnace/Indirect Contact Evaporator

Pollutant(s)	PM10	PM2.5	EC	OC	NO _x	VOC	SO ₂	NH ₃	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 50% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NO_x emission levels (Pechan, 1998).

Small source = emission levels less than 1 ton per ozone season day

Costs for stationary source NO_x control are based on an analysis of EPA's NO_x State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned for small sources. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 20 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 70% (Pechan, 2001).

Cost Effectiveness: The cost effectiveness values used in AirControlNET are \$3,870 per ton NO_x reduced from uncontrolled and \$ 2,900 per ton NO_x reduced from RACT baseline (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

SNCR is the reduction of NO_x in flue gas to N₂ and water vapor. This reduction is done with a nitrogen based reducing reagent, such as ammonia or urea. The reagent can react with a number of flue gas components. However, the NO_x reduction reaction is favored for a specific temperature range and in the presence of oxygen (EPA, 2002).

Both ammonia and urea are used as reagents. The cost of the reagent represents a large part of the annual costs of an SNCR system. Ammonia is generally less expensive than urea. However, the choice of reagent is also based on physical properties and operational considerations (EPA, 2002).

Ammonia can be utilized in either aqueous or anhydrous form. Anhydrous ammonia is a gas at atmospheric pressure and normal temperatures. There are safety issues with the use of anhydrous ammonia, as it must be transported and stored under pressure (EPA, 2002). Aqueous ammonia is generally transported and stored at a concentration of 29.4% ammonia in water.

Urea based systems have several advantages, including several safety aspects. Urea is a nontoxic, less volatile liquid that can be stored and handled more safely than ammonia. Urea solution droplets can penetrate farther into the flue gas when injected into the boiler, enhancing mixing (EPA, 2002). Because of these advantages, urea is more commonly used than ammonia in large boiler applications.

The rate of reaction determines the amount of NO_x removed from the flue gas. The important design and operational factors that affect the rate of reduction include:

Reaction temperature range;
Residence time available in the optimum temperature range;
Degree of mixing between the injected reagent and the combustion gases
Uncontrolled NO_x concentration level;
Molar ratio of injected reagent to uncontrolled NO_x ; and
Ammonia slip.

References:

EPA, 1994: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Industrial/Commercial/Institutional (ICI) Boilers," EPA,-453/R-94-022, Research Triangle Park, NC, June 1994.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

Pechan, 2001: E.H. Pechan & Associates, Inc., "Revisions to AirControlNET, and Particulate Matter Control Strategies and Cost Analysis," Revised Report, prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Surface Coat Oper; Coating Oven Htr; Nat Gas - Small Sources

Control Measure Name: Low NOx Burner

Rule Name: Not Applicable

Pechan Measure Code: N0881S, N08801

POD: 88

Application: This control is the use of low NOx burner (LNB) technology to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another.

This control is applicable to small (<1 ton NOx per OSD) natural gas-fired coating oven heater at surface coating operations with uncontrolled NOx emissions greater than 10 tons per year.

Affected SCC:

40201001 Surface Coating Operations, Coating Oven Heater, Natural Gas

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 50% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Sources are distinguished by NOx emissions (Pechan, 1998).

Small source = less than 1 ton NOx emissions per ozone season day

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). The basis of the costs are model plant data for mechanical draft heaters firing natural gas and oil contained in the Alternative Control Techniques (ACT) document (EPA, 1993). From this analysis, default cost per ton values are assigned along with a capital to annual costs ratio of 7.3. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 10 years (EPA, 1993).

Cost Effectiveness: The default cost effectiveness value used in AirControlINET is \$2,200 per ton NOx reduced from both uncontrolled and RACT (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 1998

Additional Information:

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-

AT-A-GLANCE TABLE FOR POINT SOURCES

air LNBs create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNBs create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

References:

EPA, 1993: U.S. Environmental Protection Agency, Emissions Standard Division, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document-- NO_x Emissions from Process Heaters," EPA-453/R-93-034, Research Triangle Park, NC, September 1993.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Ozone Transport Rulemaking Non-Electricity Generating Unit Cost Analysis," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, September 1998.

AT-A-GLANCE TABLE FOR UTILITY SOURCES

Source Category: Utility Boiler - Coal/Tangential

Control Measure Name: Selective Non-Catalytic Reduction (SNCR)

Rule Name: Not Applicable

Pechan Measure Code: N00201

POD: 02

Application: This control is the use of selective non-catalytic reduction add-on controls to reduce NOx emissions from tangentially coal-fired utility boilers. SNCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NOx) with a nitrogen based reducing reagent, such as ammonia or urea, to reduce the NOx into molecular nitrogen (N2) and water vapor (H2O).

This control applies to bituminous/subbituminous coal-fired electricity generation sources, including sources with atmospheric fluidized bed combustion.

Affected SCC:

10100212 Electric Generation, Pulverized Coal-Dry Bottom (Tangential) (Bituminous Coal)

10100217 Bituminous/Subbituminous Coal, Atm. Fluidized Bed Combustion-Bubbling (Bituminous)

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 35% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The cost equations used in this analysis are based on cost equations from EPA's IPM (EPA, 1998). In the IPM, model plants applying SNCR had capacities of 100 MW. The equations were scaled to develop costs for smaller or larger boilers than the model plant. The cost equations also assume a high NOx rate (≥ 0.5 pounds per MMBtu) and a capacity utilization factor of 65% were assumed for the utility boilers, as well as a 7% discount rate and 20-year lifetime of the controls.

Capital Costs (CC):

Nameplate Capacity: $\text{netdc} [=]$ MW

Total Capital Costs: $\text{TCC} = \$15.80 \text{ per kW}$

Scaling Factor: $\text{SF} = (\text{sfn} / \text{netdc})^{\text{sfe}} = (100 / \text{MW})^{0.681}$

$\text{CC (for netdc} < 500) = \text{TCC} * \text{netdc} * 1000 * \text{SF}$

$\text{CC (for netdc} > 500) = \text{TCC} * \text{netdc} * 1000$

Operating & Maintenance (O&M):

Fixed O&M: $\text{omf} = \$0.24 \text{ per kW per year}$

Variable O&M: $\text{omv} = \$0.73 \text{ mills per kW-hr}$

Capacity Factor: $\text{capfac} = 0.65$

AT-A-GLANCE TABLE FOR UTILITY SOURCES

$$\text{O\&M} = (\text{omf} * \text{netdc} * 1000) + (\text{omv} * \text{netdc} * 1000 * \text{capfac} * 8760 / 1000)$$

$$\text{Equipment Life in Years} = \text{Equiplife}$$

$$\text{Interest Rate} = i$$

$$\text{Capital Recovery Factor: CRF} = [i (1 + i)^{\text{Equiplife}}] / [(1 + i)^{\text{Equiplife}} - 1]$$

$$\text{Total Cost} = (\text{CRF} * \text{CC}) + \text{O\&M}$$

Note: All costs are in 1990 dollars.

Cost Effectiveness: Cost effectiveness is variable and based on plant size (nameplate capacity in MW) and the following factors: the total capital cost of \$15.80 per kW; the fixed O&M costs of \$0.24 per kW per year; and variable O&M costs of \$0.73 mills per kW per year (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

SNCR is the reduction of NO_x in flue gas to N₂ and water vapor. This reduction is done with a nitrogen based reducing reagent, such as ammonia or urea. The reagent can react with a number of flue gas components. However, the NO_x reduction reaction is favored for a specific temperature range and in the presence of oxygen (EPA, 2002).

Both ammonia and urea are used as reagents. The cost of the reagent represents a large part of the annual costs of an SNCR system. Ammonia is generally less expensive than urea. However, the choice of reagent is also based on physical properties and operational considerations (EPA, 2002).

References:

EPA, 1998: U.S. Environmental Protection Agency, Office of Air and Radiation, "Analyzing Electric Power Generation Under the CAAA," Washington, DC, March 1998.

AT-A-GLANCE TABLE FOR UTILITY SOURCES

Source Category: Utility Boiler - Coal/Tangential

Control Measure Name: Natural Gas Reburn (NGR)

Rule Name: Not Applicable

Pechan Measure Code: N00202

POD: 02

Application: Natural gas reburning (NGR) involves add-on controls to reduce NOx emissions. NGR is a combustion control technology in which part of the main fuel heat input is diverted to locations above the main burners, called the reburn zone. As flue gas passes through the reburn zone, a portion of the NOx formed in the main combustion zone is reduced by hydrocarbon radicals and converted to molecular nitrogen (N2).

This control applies to bituminous/subbituminous coal-fired electricity generation sources, including sources with atmospheric fluidized bed combustion.

Affected SCC:

10100212 Electric Generation, Pulverized Coal-Dry Bottom (Tangential) (Bituminous Coal)

10100217 Bituminous/Sub bituminous Coal, Atm. Fluidized Bed Combustion-Bubbling (Bituminous)

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 50% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The cost equations used in this analysis are based on cost equations from EPA's IPM (EPA, 1998). In the IPM, model plants applying NGR had capacities of 200 MW. The equations were scaled to develop costs for smaller or larger boilers than the model plant. The cost equations also assume a high NOx rate (≥ 0.5 pounds per MMBtu), a 7% discount rate, and a 20-year lifetime of the controls.

Capital Costs (CC):

Nameplate Capacity: netdc [=] MW

Total Capital Costs: TCC = \$26.90 per kW

Scaling Factor: SF = $(\text{sfn} / \text{netdc})^{\text{sfe}} = (200 / \text{MW})^{0.35}$

CC (for netdc < 500) = TCC * netdc * 1000 * SF

CC (for netdc > 500) = TCC * netdc * 1000

Operating & Maintenance (O&M):

Fixed O&M: omf = \$0.41 per kW per year

Variable O&M: omv = \$0 millions per kW-hr

Capacity Utilization Factor: capfac = 0.65

O&M = (omf * netdc * 1000) + (omv * netdc * 1000 * capfac * 8760 / 1000)

AT-A-GLANCE TABLE FOR UTILITY SOURCES

O&M Cost Components: The O&M cost breakdown is estimated using the economic analysis for a 200 megawatt unit provided in Appendix E: Cost Analysis of Reburning Systems for conventional gas reburn. The example calculation with a \$1.00 per million Btu difference between the primary fuel cost and the reburn fuel cost was used. The reference for this information is the 1998 Andover Technology Partners report for NESCAUM/MARAMA. The fuel cost differential is the dominant operating cost of NGR.

Coal Cost: \$1.50/MMBtu

Natural Gas Cost: \$2.50/MMBtu

Equipment Life in Years = Equiplife

Interest Rate = i

Capital Recovery Factor: $CRF = [i(1+i)^{Equiplife}] / [(1+i)^{Equiplife} - 1]$

Total Cost = $(CRF * CC) + O\&M$

Note: All costs are in 1990 dollars.

Cost Effectiveness: Cost effectiveness is variable and based on plant size (nameplate capacity in MW) and the following factors: the total capital cost of \$26.90 per kW, the fixed O&M of \$0.41 per kW per year, and the variable O&M of \$0 per kW-hr (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

In a reburn boiler, fuel is injected into the upper furnace region to convert the NO_x formed in the primary combustion zone to molecular N₂ and H₂O. In general, the overall process occurs within three zones of the boiler; the combustion zone, the gas reburning zone, and the burnout zone (ERG, 2000). In the combustion zone the amount of fuel is reduced and the burners may be operated at the lowest excess air level. In the gas reburning zone the fuel not used in the combustion zone is injected to create a fuel-rich region where radicals can react with NO_x to form molecular Nitrogen. In the burnout zone a separate overfire air system redirects air from the primary combustion zone to ensure complete combustion of unreacted fuel leaving the reburning zone.

Operational parameters that affect the performance of reburn include reburn zone stoichiometry, residence time in the reburn zone, reburn fuel carrier gas and temperature and O₂ levels in the burnout zone (ERG, 2000).

References:

EPA, 1998: U.S. Environmental Protection Agency, Office of Air and Radiation, "Analyzing Electric Power Generation Under the CAAA," Washington, DC, March 1998.

ERG, 2000: Eastern Research Group, Inc., "How to Incorporate the Effects of Air Pollution Control Device Efficiencies and Malfunctions into Emission Inventory Estimates," prepared for Emission Inventory Improvement Program, Point Sources Committee, July 2000.

Staudt, 1998: Staudt, James E., "Status Report on NO_x Control Technologies and Cost Effectiveness for Utility Boilers," Andover Technology Partners, North Andover, MA, prepared for NESCAUM and MARAMA, June 1998.

AT-A-GLANCE TABLE FOR UTILITY SOURCES

Source Category: Utility Boiler - Coal/Tangential

Control Measure Name: Selective Catalytic Reduction (SCR)

Rule Name: Not Applicable

Pechan Measure Code: N00203

POD: 02

Application: This control is the use of selective catalytic reduction add-on controls to tangentially coal-fired utility boilers for the reduction of NO_x emissions. SCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NO_x) with a nitrogen based reducing reagent, such as ammonia or urea, to reduce the NO_x into molecular nitrogen (N₂) and water vapor (H₂O). The SCR utilizes a catalyst to increase the NO_x removal efficiency, which allows the process to occur at lower temperatures.

This control applies to bituminous/subbituminous coal-fired electricity generation sources, including sources with atmospheric fluidized bed combustion.

Affected SCC:

10100212 Electric Generation, Pulverized Coal-Dry Bottom (Tangential) (Bituminous Coal)

10100217 Bituminous/Subbituminous Coal, Atm. Fluidized Bed Combustion-Bubbling (Bituminous)

Pollutant(s)	PM10	PM2.5	EC	OC	NO _x	VOC	SO ₂	NH ₃	CO	Hg
					√*			X		√

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 90% from uncontrolled for NO_x; 95% from uncontrolled for Hg

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The cost equations used in this analysis are based on cost equations from EPA's IPM (EPA, 1998). In the IPM, model plants applying SCR had capacities of 243 MW. The equations were scaled to develop costs for smaller or larger boilers than the model plant. The cost equations also assume a high NO_x rate (≥ 0.5 pounds per MMBtu) and a capacity utilization factor of 65% were assumed for the utility boilers, as well as a 7% discount rate and 20-year lifetime of the controls.

Capital Costs (CC):

Nameplate Capacity: netdc [=] MW

Total Capital Costs: TCC = \$100 per kW

Scaling Factor: SF = (sfn / netdc)^{sfe} = (243 / MW)^{0.27}

CC (for netdc < 600) = TCC * netdc * 1000 * SF

CC (for netdc > 600) = TCC * netdc * 1000

Operating & Maintenance (O&M):

Fixed O&M: omf = \$0.66 per kW per year

Variable O&M: omv = \$0.6 mills per kW-hr

AT-A-GLANCE TABLE FOR UTILITY SOURCES

Capacity Factor: $\text{capfac} = 0.65$

$\text{O\&M} = (\text{omf} * \text{netdc} * 1000) + (\text{omv} * \text{netdc} * 1000 * \text{capfac} * 8760 / 1000)$

Equipment Life in Years = Equiplife

Interest Rate = i

Capital Recovery Factor: $\text{CRF} = [i(1+i)^{\text{Equiplife}}] / [(1+i)^{\text{Equiplife}} - 1]$

Total Cost = $(\text{CRF} * \text{CC}) + \text{O\&M}$

O&M Cost Components: The O&M cost breakdown is estimated using the Chapter 4 costing algorithms in EPA, 2001. The fixed O&M cost is the sum of the annual maintenance material and labor cost, and is estimated to be 0.66 percent of the capital cost. This portion of the O&M cost is included in the database as maintenance labor. The NH₃ use cost equation is used to estimate chemicals costs. The annual replacement cost equation is used to estimate replacement materials costs. The energy requirement cost equation is used to estimate electricity costs.

Electricity cost = \$0.03/kWhr

Ammonia cost = \$225/ton

The above O&M component costs are in 2000 dollars. The model plant size used to estimate utility boiler O&M cost components is 750 MMBtu/hour.

Note: All costs are in 1999 dollars.

Cost Effectiveness: Cost effectiveness is variable and based on plant size (nameplate capacity in MW) and the following factors: the total capital cost of \$100 per kW; the fixed O&M cost of \$0.66 per kW per year; and the variable O&M cost of \$0.6 mills per KW-hr (1999\$).

Comments:

Status: Demonstrated

Last Reviewed: 2005

Additional Information:

Like SNCR, SCR is based on the chemical reduction of the NO_x molecule. The primary difference between SNCR and SCR is that SCR uses a metal-based catalyst to increase the rate of reaction (EPA, 2002). A nitrogen based reducing reagent, such as ammonia or urea, is injected into the flue gas. The reagent reacts selectively with the flue gas NO_x within a specific temperature range and in the presence of the catalyst and oxygen to reduce the NO_x.

Selective Catalytic Reduction (SCR) systems are among the post-combustion NO_x control systems that can be effective in controlling mercury. This is based on recent pilot-scale tests that indicate that SNCR and SCR systems may enhance Hg capture under some conditions by oxidizing Hg⁰ (Massachusetts, 2002).

Researches are investigating the possibility of Hg⁰ to Hg²⁺ conversion in SCR systems as a possible result of ammonia on fly ash mercury reactions. In the SCR process, a catalyst (such as vanadium, titanium, platinum, or zeolite) is used in a bed reactor, and the NO_x reduction occurs at the surface of the catalyst bed with the help of a reducing agent (diluted ammonia or urea, which generates ammonia in the process). The ammonia mixture is injected into the flue gas upstream of the metal catalyst bed reactor, which is located upstream of a PM or SO₂ control device (usually

AT-A-GLANCE TABLE FOR UTILITY SOURCES

between the economizer outlet and air heater inlet, where temperatures range from 230 to 400oC).

Recent pilot-scale tests indicate that SCR systems can enhance Hg capture under some conditions by oxidizing Hg0. On the plant-size scale, only one set of tests have been performed to measure the effectiveness of SCR systems. Application of SCR system, combined with spray dryer absorber was tested at a plant which was firing bituminous coal. The test results indicated greater than 95 percent mercury removal for the combined co-control systems (Massachusetts, 2002).

References:

EPA, 1998: U.S. Environmental Protection Agency, Office of Air and Radiation, "Analyzing Electric Power Generation Under the CAAA," Washington, DC, March 1998.

Massachusetts, 2002: Commonwealth of Massachusetts, Department of Environmental Protection, Executive Office of Environmental Affairs, Division of Planning and Evaluation, Bureau of Waste Prevention, "Evaluation Of The Technological and Economic Feasibility of Controlling and Eliminating Mercury Emissions from the Combustion of Solid Fossil Fuel, Pursuant To 310 CMR 7.29 - Emissions Standards For Power Plants," Downloaded from <http://www.state.ma.us/dep/bwp/daqc/daqcpubs.htm#other>, December 2002.

EPA, 2001: U.S. Environmental Protection, Office of Research and Development, "Cost of Selective Catalytic Reduction (SCR) Application for NOx Control on Coal-Fired Boilers," EPA-600/R-01-087, Research Triangle Park, NC, October 2001.

EPA, 2004: U.S. Environmental Protection Agency, Clean Air Market Division, "Updating Performance and Cost of Nox Control Technologies in the Integrated Planning Model" Paper # 137

AT-A-GLANCE TABLE FOR UTILITY SOURCES

Source Category: Utility Boiler - Coal/Tangential

Control Measure Name: Low Nox Coal-and-Air Nozzles with cross-Coupled Overfire Air (LNC1)

Rule Name: Not Applicable

Pechan Measure Code: N00903

POD: 02

Application: This control is the use of low NOx burner (LNB) technology to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another.

This control applies to wall fired (coal) utility boilers

Affected SCC:

10100212 Electric Generation, Pulverized Coal-Dry Bottom (Tangential) (Bituminous Coal)

10100217 Bituminous/Subbituminous Coal, Atm. Fluidized Bed Combustion-Bubbling (Bituminous)

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 33% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The cost equations used in this analysis are based on cost equations from EPA's IPM (EPA, 1998). In the IPM, model plants applying LNB had capacities of 300 MW. The equations were scaled to develop costs for smaller or larger boilers than the model plant. The cost equations also assume a capacity utilization factor of 85% for the utility boilers, as well as a 7% discount rate and 15-year lifetime of the controls.

Capital Costs (CC):

Nameplate Capacity: netdc [=] MW

Total Capital Costs: TCC = \$9.1 per kW

Scaling Factor: SF = (sfn / netdc)^{sfe} = (300 / MW)^{0.359}

CC (for netdc < 500) = TCC * netdc * 1000 * SF

CC (for netdc > 500) = TCC * netdc * 1000

Operating & Maintenance (O&M):

Fixed O&M: omf = \$0.14 per kW per year

Variable O&M: omv = \$0.0 mills per kW-hr

Capacity Factor: capfac = 0.85

O&M = (omf * netdc * 1000) + (omv * netdc * 1000 * capfac * 8760 / 1000)

Equipment Life in Years = Equiplife

AT-A-GLANCE TABLE FOR UTILITY SOURCES

Interest Rate = i

Capital Recovery Factor: $CRF = [i(1+i)^{\text{Equiplife}}] / [(1+i)^{\text{Equiplife}} - 1]$

Total Cost = $(CRF * CC) + O\&M$

O&M Cost Components: With the retrofit of combustion controls, the boiler unburned carbon may increase. This increase results in a reduction in boiler efficiency, requiring more coal to be burned to maintain the boiler output. As the coal firing rate increases, there are corresponding increases in the solid waste generation and auxiliary power usage. The O&M costs were evaluated for tangential-fired boilers only. With no changes in the capital cost for wall-fired boilers, the fixed O&M costs, generally taken as a function of the capital cost, are not expected to vary. Also, no changes in the variable O&M costs are expected, since unburned carbon assumptions are unchanged.

For tangential-fired boilers, the general maintenance cost was conservatively taken as 1.5 percent of the total project cost for each technology. Also, a plant capacity factor of 85 percent was assumed.

Coal Cost: \$1.20/MMBtu

Solid waste disposal: \$12/ton

Auxiliary power: 25 mills/KWh

Note: All costs are in 1999 dollars.

Cost Effectiveness: Cost effectiveness is variable and based on plant size (nameplate capacity in MW) and the following factors: the total capital cost of \$9.1 per kW; the fixed O&M costs of \$0.14 per kW per year; and variable O&M costs of \$0.0 mills per kW per year (1999\$).

Comments:

Status: Demonstrated

Last Reviewed: 2005

Additional Information:

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNBs create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNBs create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

References:

EPA, 2004: U.S. Environmental Protection Agency, Clean Air Market Division, "Updating Performance and Cost of Nox Control Technologies in the Integrated Planning Model" Paper # 137

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

AT-A-GLANCE TABLE FOR UTILITY SOURCES

Source Category: Utility Boiler - Coal/Tangential

Control Measure Name: Low Nox Coal-and-Air Nozzles with separated Overfire Air (LNC2)

Rule Name: Not Applicable

Pechan Measure Code: N00904

POD: 02

Application: This control is the use of low NOx burner (LNB) technology to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another.

This control applies to wall fired (coal) utility boilers

Affected SCC:

10100212 Electric Generation, Pulverized Coal-Dry Bottom (Tangential) (Bituminous Coal)

10100217 Bituminous/Subbituminous Coal, Atm. Fluidized Bed Combustion-Bubbling (Bituminous)

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 38% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The cost equations used in this analysis are based on cost equations from EPA's IPM (EPA, 1998). In the IPM, model plants applying LNB had capacities of 300 MW. The equations were scaled to develop costs for smaller or larger boilers than the model plant. The cost equations also assume a capacity utilization factor of 85% for the utility boilers, as well as a 7% discount rate and 15-year lifetime of the controls.

Capital Costs (CC):

Nameplate Capacity: netdc [=] MW

Total Capital Costs: TCC = \$12.71 per kW

Scaling Factor: SF = (sfn / netdc)^{sfe} = (300 / MW)^{0.359}

CC (for netdc < 500) = TCC * netdc * 1000 * SF

CC (for netdc > 500) = TCC * netdc * 1000

Operating & Maintenance (O&M):

Fixed O&M: omf = \$0.19 per kW per year

Variable O&M: omv = \$0.024 mills per kW-hr

Capacity Factor: capfac = 0.85

O&M = (omf * netdc * 1000) + (omv * netdc * 1000 * capfac * 8760 / 1000)

Equipment Life in Years = Equiplife

AT-A-GLANCE TABLE FOR UTILITY SOURCES

Interest Rate = i

Capital Recovery Factor: $CRF = [i(1+i)^{\text{Equiplife}}] / [(1+i)^{\text{Equiplife}} - 1]$

Total Cost = $(CRF * CC) + O\&M$

O&M Cost Components: With the retrofit of combustion controls, the boiler unburned carbon may increase. This increase results in a reduction in boiler efficiency, requiring more coal to be burned to maintain the boiler output. As the coal firing rate increases, there are corresponding increases in the solid waste generation and auxiliary power usage. The O&M costs were evaluated for tangential-fired boilers only. With no changes in the capital cost for wall-fired boilers, the fixed O&M costs, generally taken as a function of the capital cost, are not expected to vary. Also, no changes in the variable O&M costs are expected, since unburned carbon assumptions are unchanged.

For tangential-fired boilers, the general maintenance cost was conservatively taken as 1.5 percent of the total project cost for each technology. Also, a plant capacity factor of 85 percent was assumed.

Coal Cost: \$1.20/MMBtu

Solid waste disposal: \$12/ton

Auxiliary power: 25 mills/KWh

Note: All costs are in 1999 dollars.

Cost Effectiveness: Cost effectiveness is variable and based on plant size (nameplate capacity in MW) and the following factors: the total capital cost of \$12.71 per kW; the fixed O&M costs of \$0.19 per kW per year; and variable O&M costs of \$0.024 mills per kW per year (1999\$).

Comments:

Status: Demonstrated

Last Reviewed: 2005

Additional Information:

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNBs create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNBs create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

References:

EPA, 2004: U.S. Environmental Protection Agency, Clean Air Market Division, "Updating Performance and Cost of Nox Control Technologies in the Integrated Planning Model" Paper # 137

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

AT-A-GLANCE TABLE FOR UTILITY SOURCES

Source Category: Utility Boiler - Coal/Tangential

Control Measure Name: Low Nox Coal-and-Air Nozzles with Close-Coupled and Separated Overfire Air (LNC3)

Rule Name: Not Applicable

Pechan Measure Code: N00905

POD: 02

Application: This control is the use of low NOx burner (LNB) technology to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another.

This control applies to wall fired (coal) utility boilers

Affected SCC:

10100212 Electric Generation, Pulverized Coal-Dry Bottom (Tangential) (Bituminous Coal)

10100217 Bituminous/Subbituminous Coal, Atm. Fluidized Bed Combustion-Bubbling (Bituminous)

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 53% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The cost equations used in this analysis are based on cost equations from EPA's IPM (EPA, 1998). In the IPM, model plants applying LNB had capacities of 300 MW. The equations were scaled to develop costs for smaller or larger boilers than the model plant. The cost equations also assume a capacity utilization factor of 85% for the utility boilers, as well as a 7% discount rate and 15-year lifetime of the controls.

Capital Costs (CC):

Nameplate Capacity: netdc [=] MW

Total Capital Costs: TCC = \$14.52 per kW

Scaling Factor: SF = (sfn / netdc)^{sfe} = (300 / MW)^{0.359}

CC (for netdc < 500) = TCC * netdc * 1000 * SF

CC (for netdc > 500) = TCC * netdc * 1000

Operating & Maintenance (O&M):

Fixed O&M: omf = \$0.22 per kW per year

Variable O&M: omv = \$0.024 mills per kW-hr

Capacity Factor: capfac = 0.85

O&M = (omf * netdc * 1000) + (omv * netdc * 1000 * capfac * 8760 / 1000)

AT-A-GLANCE TABLE FOR UTILITY SOURCES

Equipment Life in Years = Equiplife

Interest Rate = i

Capital Recovery Factor: $CRF = [i(1+i)^{\text{Equiplife}}] / [(1+i)^{\text{Equiplife}} - 1]$

Total Cost = $(CRF * CC) + O\&M$

O&M Cost Components: With the retrofit of combustion controls, the boiler unburned carbon may increase. This increase results in a reduction in boiler efficiency, requiring more coal to be burned to maintain the boiler output. As the coal firing rate increases, there are corresponding increases in the solid waste generation and auxiliary power usage. The O&M costs were evaluated for tangential-fired boilers only. With no changes in the capital cost for wall-fired boilers, the fixed O&M costs, generally taken as a function of the capital cost, are not expected to vary. Also, no changes in the variable O&M costs are expected, since unburned carbon assumptions are unchanged.

For tangential-fired boilers, the general maintenance cost was conservatively taken as 1.5 percent of the total project cost for each technology. Also, a plant capacity factor of 85 percent was assumed.

Coal Cost: \$1.20/MMBtu

Solid waste disposal: \$12/ton

Auxiliary power: 25 mills/KWh

Note: All costs are in 1999 dollars.

Cost Effectiveness: Cost effectiveness is variable and based on plant size (nameplate capacity in MW) and the following factors: the total capital cost of \$14.52 per kW; the fixed O&M costs of \$0.22 per kW per year; and variable O&M costs of \$0.024 mills per kW per year (1999\$).

Comments:

Status: Demonstrated

Last Reviewed: 2005

Additional Information:

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNBs create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNBs create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

References:

EPA, 2004: U.S. Environmental Protection Agency, Clean Air Market Division, "Updating Performance and Cost of Nox Control Technologies in the Integrated Planning Model" Paper # 137

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

AT-A-GLANCE TABLE FOR UTILITY SOURCES

Source Category: Utility Boiler - Coal/Tangential

Control Measure Name: Low Nox Coal-and-Air Nozzles with cross-Coupled Overfire Air (LNC1)

Rule Name: Not Applicable

Pechan Measure Code: N00908

POD: 10

Application: This control is the use of low NOx burner (LNB) technology to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another.

This control applies to wall fired (coal) utility boilers

Affected SCC:

10100226 Electric Generation, Pulverized Coal: Dry Bottom Tangential (Subbituminous Coal)

10100302 Electric Generation, Pulverized Coal: Dry Bottom, Tangential Fired

10100317 Electric Generation, Atmospheric Fluidized Bed Combustion - Bubbling Bed

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 43% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The cost equations used in this analysis are based on cost equations from EPA's IPM (EPA, 1998). In the IPM, model plants applying LNB had capacities of 300 MW. The equations were scaled to develop costs for smaller or larger boilers than the model plant. The cost equations also assume a capacity utilization factor of 85% for the utility boilers, as well as a 7% discount rate and 15-year lifetime of the controls.

Capital Costs (CC):

Nameplate Capacity: netdc [=] MW

Total Capital Costs: TCC = \$9.1 per kW

Scaling Factor: SF = (sfn / netdc)^{sfe} = (300 / MW)^{0.359}

CC (for netdc < 500) = TCC * netdc * 1000 * SF

CC (for netdc > 500) = TCC * netdc * 1000

Operating & Maintenance (O&M):

Fixed O&M: omf = \$0.14 per kW per year

Variable O&M: omv = \$0.0 mills per kW-hr

Capacity Factor: capfac = 0.85

O&M = (omf * netdc * 1000) + (omv * netdc * 1000 * capfac * 8760 / 1000)

AT-A-GLANCE TABLE FOR UTILITY SOURCES

Equipment Life in Years = Equiplife

Interest Rate = i

Capital Recovery Factor: $CRF = [i(1+i)^{\text{Equiplife}}] / [(1+i)^{\text{Equiplife}} - 1]$

Total Cost = $(CRF * CC) + O\&M$

O&M Cost Components: With the retrofit of combustion controls, the boiler unburned carbon may increase. This increase results in a reduction in boiler efficiency, requiring more coal to be burned to maintain the boiler output. As the coal firing rate increases, there are corresponding increases in the solid waste generation and auxiliary power usage. The O&M costs were evaluated for tangential-fired boilers only. With no changes in the capital cost for wall-fired boilers, the fixed O&M costs, generally taken as a function of the capital cost, are not expected to vary. Also, no changes in the variable O&M costs are expected, since unburned carbon assumptions are unchanged.

For tangential-fired boilers, the general maintenance cost was conservatively taken as 1.5 percent of the total project cost for each technology. Also, a plant capacity factor of 85 percent was assumed.

Coal Cost: \$1.20/MMBtu

Solid waste disposal: \$12/ton

Auxiliary power: 25 mills/KWh

Note: All costs are in 1999 dollars.

Cost Effectiveness: Cost effectiveness is variable and based on plant size (nameplate capacity in MW) and the following factors: the total capital cost of \$9.1 per kW; the fixed O&M costs of \$0.14 per kW per year; and variable O&M costs of \$0.0 mills per kW per year (1999\$).

Comments:

Status: Demonstrated

Last Reviewed: 2005

Additional Information:

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNBs create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNBs create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

References:

EPA, 2004: U.S. Environmental Protection Agency, Clean Air Market Division, "Updating Performance and Cost of Nox Control Technologies in the Integrated Planning Model" Paper # 137

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

AT-A-GLANCE TABLE FOR UTILITY SOURCES

Source Category: Utility Boiler - Coal/Tangential

Control Measure Name: Low Nox Coal-and-Air Nozzles with separated Overfire Air (LNC2)

Rule Name: Not Applicable

Pechan Measure Code: N00909

POD: 10

Application: This control is the use of low NOx burner (LNB) technology to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another.

This control applies to wall fired (coal) utility boilers

Affected SCC:

10100226 Electric Generation, Pulverized Coal: Dry Bottom Tangential (Subbituminous Coal)

10100302 Electric Generation, Pulverized Coal: Dry Bottom, Tangential Fired

10100317 Electric Generation, Atmospheric Fluidized Bed Combustion - Bubbling Bed

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 48% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The cost equations used in this analysis are based on cost equations from EPA's IPM (EPA, 1998). In the IPM, model plants applying LNB had capacities of 300 MW. The equations were scaled to develop costs for smaller or larger boilers than the model plant. The cost equations also assume a capacity utilization factor of 85% for the utility boilers, as well as a 7% discount rate and 15-year lifetime of the controls.

Capital Costs (CC):

Nameplate Capacity: netdc [=] MW

Total Capital Costs: TCC = \$12.71 per kW

Scaling Factor: SF = (sfn / netdc)^{sfe} = (300 / MW)^{0.359}

CC (for netdc < 500) = TCC * netdc * 1000 * SF

CC (for netdc > 500) = TCC * netdc * 1000

Operating & Maintenance (O&M):

Fixed O&M: omf = \$0.19 per kW per year

Variable O&M: omv = \$0.024 mills per kW-hr

Capacity Factor: capfac = 0.85

O&M = (omf * netdc * 1000) + (omv * netdc * 1000 * capfac * 8760 / 1000)

AT-A-GLANCE TABLE FOR UTILITY SOURCES

Equipment Life in Years = Equiplife

Interest Rate = i

Capital Recovery Factor: $CRF = [i(1+i)^{\text{Equiplife}}] / [(1+i)^{\text{Equiplife}} - 1]$

Total Cost = $(CRF * CC) + O\&M$

O&M Cost Components: With the retrofit of combustion controls, the boiler unburned carbon may increase. This increase results in a reduction in boiler efficiency, requiring more coal to be burned to maintain the boiler output. As the coal firing rate increases, there are corresponding increases in the solid waste generation and auxiliary power usage. The O&M costs were evaluated for tangential-fired boilers only. With no changes in the capital cost for wall-fired boilers, the fixed O&M costs, generally taken as a function of the capital cost, are not expected to vary. Also, no changes in the variable O&M costs are expected, since unburned carbon assumptions are unchanged.

For tangential-fired boilers, the general maintenance cost was conservatively taken as 1.5 percent of the total project cost for each technology. Also, a plant capacity factor of 85 percent was assumed.

Coal Cost: \$1.20/MMBtu

Solid waste disposal: \$12/ton

Auxiliary power: 25 mills/KWh

Note: All costs are in 1999 dollars.

Cost Effectiveness: Cost effectiveness is variable and based on plant size (nameplate capacity in MW) and the following factors: the total capital cost of \$12.71 per kW; the fixed O&M costs of \$0.19 per kW per year; and variable O&M costs of \$0.024 mills per kW per year (1999\$).

Comments:

Status: Demonstrated

Last Reviewed: 2005

Additional Information:

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNBs create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNBs create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

References:

EPA, 2004: U.S. Environmental Protection Agency, Clean Air Market Division, "Updating Performance and Cost of Nox Control Technologies in the Integrated Planning Model" Paper # 137

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

AT-A-GLANCE TABLE FOR UTILITY SOURCES

Source Category: Utility Boiler - Coal/Tangential

Control Measure Name: Low Nox Coal-and-Air Nozzles with Close-Coupled and Separated Overfire Air (LNC3)

Rule Name: Not Applicable

Pechan Measure Code: N00910

POD: 10

Application: This control is the use of low NOx burner (LNB) technology to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another.

This control applies to wall fired (coal) utility boilers

Affected SCC:

10100226 Electric Generation, Pulverized Coal: Dry Bottom Tangential (Subbituminous Coal)

10100302 Electric Generation, Pulverized Coal: Dry Bottom, Tangential Fired

10100317 Electric Generation, Atmospheric Fluidized Bed Combustion - Bubbling Bed

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 58% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The cost equations used in this analysis are based on cost equations from EPA's IPM (EPA, 1998). In the IPM, model plants applying LNB had capacities of 300 MW. The equations were scaled to develop costs for smaller or larger boilers than the model plant. The cost equations also assume a capacity utilization factor of 85% for the utility boilers, as well as a 7% discount rate and 15-year lifetime of the controls.

Capital Costs (CC):

Nameplate Capacity: netdc [=] MW

Total Capital Costs: TCC = \$14.52 per kW

Scaling Factor: SF = (sfn / netdc)^{sfe} = (300 / MW)^{0.359}

CC (for netdc < 500) = TCC * netdc * 1000 * SF

CC (for netdc > 500) = TCC * netdc * 1000

Operating & Maintenance (O&M):

Fixed O&M: omf = \$0.22 per kW per year

Variable O&M: omv = \$0.024 mills per kW-hr

Capacity Factor: capfac = 0.85

O&M = (omf * netdc * 1000) + (omv * netdc * 1000 * capfac * 8760 / 1000)

AT-A-GLANCE TABLE FOR UTILITY SOURCES

Equipment Life in Years = Equiplife

Interest Rate = i

Capital Recovery Factor: $CRF = [i(1+i)^{\text{Equiplife}}] / [(1+i)^{\text{Equiplife}} - 1]$

Total Cost = $(CRF * CC) + O\&M$

O&M Cost Components: With the retrofit of combustion controls, the boiler unburned carbon may increase. This increase results in a reduction in boiler efficiency, requiring more coal to be burned to maintain the boiler output. As the coal firing rate increases, there are corresponding increases in the solid waste generation and auxiliary power usage. The O&M costs were evaluated for tangential-fired boilers only. With no changes in the capital cost for wall-fired boilers, the fixed O&M costs, generally taken as a function of the capital cost, are not expected to vary. Also, no changes in the variable O&M costs are expected, since unburned carbon assumptions are unchanged.

For tangential-fired boilers, the general maintenance cost was conservatively taken as 1.5 percent of the total project cost for each technology. Also, a plant capacity factor of 85 percent was assumed.

Coal Cost: \$1.20/MMBtu

Solid waste disposal: \$12/ton

Auxiliary power: 25 mills/KWh

Note: All costs are in 1999 dollars.

Cost Effectiveness: Cost effectiveness is variable and based on plant size (nameplate capacity in MW) and the following factors: the total capital cost of \$14.52 per kW; the fixed O&M costs of \$0.22 per kW per year; and variable O&M costs of \$0.024 mills per kW per year (1999\$).

Comments:

Status: Demonstrated

Last Reviewed: 2005

Additional Information:

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNBs create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNBs create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

References:

EPA, 2004: U.S. Environmental Protection Agency, Clean Air Market Division, "Updating Performance and Cost of Nox Control Technologies in the Integrated Planning Model" Paper # 137

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

AT-A-GLANCE TABLE FOR UTILITY SOURCES

Source Category: Utility Boiler - Coal/Wall

Control Measure Name: Selective Non-Catalytic Reduction (SNCR)

Rule Name: Not Applicable

Pechan Measure Code: N00101

POD: 01

Application: This control is the reduction of NOx emission through selective non-catalytic reduction add-on controls to wall fired (coal) utility boilers. SNCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NOx) with a nitrogen based reducing reagent, such as ammonia or urea, to reduce the NOx into molecular nitrogen (N2) and water vapor (H2O).

This control applies to pulverized-dry bottom coal-fired electricity generation sources.

Affected SCC:

10100202 Electric Generation, Pulverized-Dry Bottom (Bituminous Coal)

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 35% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The cost equations used in this analysis are based on cost equations from EPA's IPM (EPA, 1998). In the IPM, model plants applying SNCR had capacities of 100 MW. The equations were scaled to develop costs for smaller or larger boilers than the model plant. The cost equations also assume a high NOx rate (≥ 0.5 pounds per MMBtu) and a capacity utilization factor of 65% were assumed for the utility boilers, as well as a 7% discount rate and 20-year lifetime of the controls.

Capital Costs (CC):

Nameplate Capacity: netdc [=] MW

Total Capital Costs: TCC = \$15.80 per kW

Scaling Factor: SF = (sfn / netdc)^{sfe} = (100 / MW)^{0.681}

CC (for netdc < 500) = TCC * netdc * 1000 * SF

CC (for netdc > 500) = TCC * netdc * 1000

Operating & Maintenance (O&M):

Fixed O&M: omf = \$0.24 per kW per year

Variable O&M: omv = \$0.73 mills per kW-hr

Capacity Factor: capfac = 0.65

O&M = (omf * netdc * 1000) + (omv * netdc * 1000 * capfac * 8760 / 1000)

AT-A-GLANCE TABLE FOR UTILITY SOURCES

Equipment Life in Years = Equiplife

Interest Rate = i

Capital Recovery Factor: $CRF = [i(1+i)^{\text{Equiplife}}] / [(1+i)^{\text{Equiplife}} - 1]$

Total Cost = $(CRF * CC) + O\&M$

O&M Cost Components: The O&M cost breakdown is estimated using the detailed information in the OAQPS Control Cost Manual-Section 4-NO_x Controls. The example problem in subsection 1.5 is used as an example for computing typical capital and annual costs of a retrofit SNCR system being applied to a 1,000 MMBtu/hour wall-fired, industrial boiler firing sub-bituminous coal. In this analysis, the SNCR system is assumed to operate for 5 months of the year with a capacity factor of 65 percent, resulting in a total capacity factor of 27 percent. The total variable direct annual cost is the sum of the cost of the reagent, electricity, water, coal, and ash. Indirect annual costs are zero.

Electricity Cost: \$0.05 \$/kW-hr

Coal Cost: \$1.60/MMBtu

Note: All costs are in 1990 dollars.

Cost Effectiveness: Cost effectiveness is variable and based on plant size (nameplate capacity in MW) and the following factors: the total capital cost of \$15.80 per kW; the fixed O&M costs of \$0.24 per kW per year; and variable O&M costs of \$0.73 mills per kW per year (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

SNCR is the reduction of NO_x in flue gas to N₂ and water vapor. This reduction is done with a nitrogen based reducing reagent, such as ammonia or urea. The reagent can react with a number of flue gas components. However, the NO_x reduction reaction is favored for a specific temperature range and in the presence of oxygen (EPA, 2002).

Both ammonia and urea are used as reagents. The cost of the reagent represents a large part of the annual costs of an SNCR system. Ammonia is generally less expensive than urea. However, the choice of reagent is also based on physical properties and operational considerations (EPA, 2002).

References:

EPA, 1998: U.S. Environmental Protection Agency, Office of Air and Radiation, "Analyzing Electric Power Generation Under the CAAA," Washington, DC, March 1998.

AT-A-GLANCE TABLE FOR UTILITY SOURCES

Source Category: Utility Boiler - Coal/Wall

Control Measure Name: Natural Gas Reburn (NGR)

Rule Name: Not Applicable

Pechan Measure Code: N00102

POD: 01

Application: Natural gas reburning (NGR) involves add-on controls to reduce NO_x emissions. NGR is a combustion control technology in which part of the main fuel heat input is diverted to locations above the main burners, called the reburn zone. As flue gas passes through the reburn zone, a portion of the NO_x formed in the main combustion zone is reduced by hydrocarbon radicals and converted to molecular nitrogen (N₂).

This control applies to pulverized-dry bottom coal-fired electricity generation sources.

Affected SCC:

10100202 Electric Generation, Pulverized-Dry Bottom (Bituminous Coal)

Pollutant(s)	PM10	PM2.5	EC	OC	NO _x	VOC	SO ₂	NH ₃	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 50% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The cost equations used in this analysis are based on cost equations from EPA's IPM (EPA, 1998). In the IPM, model plants applying NGR had capacities of 200 MW. The equations were scaled to develop costs for smaller or larger boilers than the model plant. The cost equations also assume a high NO_x rate (≥ 0.5 pounds per MMBtu), a 7% discount rate, and a 20-year lifetime of the controls.

Capital Costs (CC):

Nameplate Capacity: netdc [=] MW

Total Capital Costs: TCC = \$26.90 per kW

Scaling Factor: SF = (sfn / netdc)^{sfe} = (200 / MW)^{0.35}

CC (for netdc < 500) = TCC * netdc * 1000 * SF

CC (for netdc > 500) = TCC * netdc * 1000

Operating & Maintenance (O&M):

Fixed O&M: omf = \$0.41 per kW per year

Variable O&M: omv = \$0 millions per kW-hr

Capacity Utilization Factor: capfac = 0.65

O&M = (omf * netdc * 1000) + (omv * netdc * 1000 * capfac * 8760 / 1000)

AT-A-GLANCE TABLE FOR UTILITY SOURCES

Equipment Life in Years = Equiplife
Interest Rate = i

Capital Recovery Factor: $CRF = [i(1+i)^{\text{Equiplife}}] / [(1+i)^{\text{Equiplife}} - 1]$

Total Cost = $(CRF * CC) + O\&M$

O&M Cost Components: The O&M cost breakdown is estimated using the economic analysis for a 200 megawatt unit provided in Appendix E: Cost Analysis of Reburning Systems for conventional gas reburn. The example calculation with a \$1.00 per million Btu difference between the primary fuel cost and the reburn fuel cost was used. The reference for this information is the 1998 Andover Technology Partners report for NESCAUM/MARAMA. The fuel cost differential is the dominant operating cost of NGR.

Coal Cost: \$1.50/MMBtu
Natural Gas Cost: \$2.50/MMBtu

Note: All costs are in 1990 dollars.

Cost Effectiveness: Cost effectiveness is variable and based on plant size (nameplate capacity in MW) and the following factors: the total capital cost of \$26.90 per kW, the fixed O&M of \$0.41 per kW per year, and the variable O&M of \$0 per kW-hr (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

In a reburn boiler, fuel is injected into the upper furnace region to convert the NO_x formed in the primary combustion zone to molecular N₂ and H₂O. In general, the overall process occurs within three zones of the boiler; the combustion zone, the gas reburning zone, and the burnout zone (ERG, 2000). In the combustion zone the amount of fuel is reduced and the burners may be operated at the lowest excess air level. In the gas reburning zone the fuel not used in the combustion zone is injected to create a fuel-rich region where radicals can react with NO_x to form molecular Nitrogen. In the burnout zone a separate overfire air system redirects air from the primary combustion zone to ensure complete combustion of unreacted fuel leaving the reburning zone.

Operational parameters that affect the performance of reburn include reburn zone stoichiometry, residence time in the reburn zone, reburn fuel carrier gas and temperature and O₂ levels in the burnout zone (ERG, 2000).

References:

EPA, 1998: U.S. Environmental Protection Agency, Office of Air and Radiation, "Analyzing Electric Power Generation Under the CAAA," Washington, DC, March 1998.

ERG, 2000: Eastern Research Group, Inc., "How to Incorporate the Effects of Air Pollution Control Device Efficiencies and Malfunctions into Emission Inventory Estimates," prepared for Emission Inventory Improvement Program, Point Sources Committee, July 2000.

Staudt, 1998: Staudt, James E., "Status Report on NO_x Control Technologies and Cost Effectiveness for Utility Boilers," Andover Technology Partners, North Andover, MA, prepared for

AT-A-GLANCE TABLE FOR UTILITY SOURCES

NESCAUM and MARAMA, June 1998.

AT-A-GLANCE TABLE FOR UTILITY SOURCES

Source Category: Utility Boiler - Coal/Wall

Control Measure Name: Selective Catalytic Reduction (SCR)

Rule Name: Not Applicable

Pechan Measure Code: N00103

POD: 01

Application: This control is the use of selective catalytic reduction add-on controls to coal/wall fired utility boilers for the reduction of NOx emissions. SCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NOx) with a nitrogen based reducing reagent, such as ammonia or urea, to reduce the NOx into molecular nitrogen (N2) and water vapor (H2O). The SCR utilizes a catalyst to increase the NOx removal efficiency, which allows the process to occur at lower temperatures.

This control applies to pulverized-dry bottom coal-fired electricity generation sources.

Affected SCC:

10100202 Electric Generation, Pulverized-Dry Bottom (Bituminous Coal)

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 90% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The cost equations used in this analysis are based on cost equations from EPA's IPM (EPA, 1998). In the IPM, model plants applying SCR had capacities of 243 MW. The equations were scaled to develop costs for smaller or larger boilers than the model plant. The cost equations also assume a high NOx rate (≥ 0.5 pounds per MMBtu) and a capacity utilization factor of 65% were assumed for the utility boilers, as well as a 7% discount rate and 20-year lifetime of the controls.

Capital Costs (CC):

Nameplate Capacity: $\text{netdc} [=] \text{MW}$

Total Capital Costs: $\text{TCC} = \$100 \text{ per kW}$

Scaling Factor: $\text{SF} = (\text{sfn} / \text{netdc})^{\text{sfe}} = (243 / \text{MW})^{0.27}$

$\text{CC (for netdc} < 600) = \text{TCC} * \text{netdc} * 1000 * \text{SF}$

$\text{CC (for netdc} > 600) = \text{TCC} * \text{netdc} * 1000$

Operating & Maintenance (O&M):

Fixed O&M: $\text{omf} = \$0.66 \text{ per kW per year}$

Variable O&M: $\text{omv} = \$0.6 \text{ mills per kW-hr}$

Capacity Factor: $\text{capfac} = 0.65$

AT-A-GLANCE TABLE FOR UTILITY SOURCES

$$\text{O\&M} = (\text{omf} * \text{netdc} * 1000) + (\text{omv} * \text{netdc} * 1000 * \text{capfac} * 8760 / 1000)$$

Equipment Life in Years = Equiplife

Interest Rate = i

$$\text{Capital Recovery Factor: CRF} = [i(1+i)^{\text{Equiplife}}] / [(1+i)^{\text{Equiplife}} - 1]$$

$$\text{Total Cost} = (\text{CRF} * \text{CC}) + \text{O\&M}$$

O&M Cost Components: The O&M cost breakdown is estimated using the Chapter 4 costing algorithms in EPA, 2001. The fixed O&M cost is the sum of the annual maintenance material and labor cost, and is estimated to be 0.66 percent of the capital cost. This portion of the O&M cost is included in the database as maintenance labor. The NH₃ use cost equation is used to estimate chemicals costs. The annual replacement cost equation is used to estimate replacement materials costs. The energy requirement cost equation is used to estimate electricity costs.

Electricity cost = \$0.03/kWhr

Ammonia cost = \$225/ton

The above O&M component costs are in 2000 dollars. The model plant size used to estimate utility boiler O&M cost components is 750 MMBtu/hour.

Note: All costs are in 1999 dollars.

Cost Effectiveness: Cost effectiveness is variable and based on plant size (nameplate capacity in MW) and the following factors: the total capital cost of \$100 per kW; the fixed O&M cost of \$0.66 per kW per year; and the variable O&M cost of \$0.6 mills per KW-hr (1999\$).

Comments:

Status: Demonstrated

Last Reviewed: 2005

Additional Information:

Like SNCR, SCR is based on the chemical reduction of the NO_x molecule. The primary difference between SNCR and SCR is that SCR uses a metal-based catalyst to increase the rate of reaction (EPA, 2002). A nitrogen based reducing reagent, such as ammonia or urea, is injected into the flue gas. The reagent reacts selectively with the flue gas NO_x within a specific temperature range and in the presence of the catalyst and oxygen to reduce the NO_x.

References:

EPA, 1998: U.S. Environmental Protection Agency, Office of Air and Radiation, "Analyzing Electric Power Generation Under the CAAA," Washington, DC, March 1998.

EPA, 2001: U.S. Environmental Protection, Office of Research and Development, "Cost of Selective Catalytic Reduction (SCR) Application for NO_x Control on Coal-Fired Boilers," EPA-600/R-01-087, Research Triangle Park, NC, October 2001.

EPA, 2004: U.S. Environmental Protection Agency, Clean Air Market Division, "Updating Performance and Cost of NO_x Control Technologies in the Integrated Planning Model" Paper # 137

AT-A-GLANCE TABLE FOR UTILITY SOURCES

Source Category: Utility Boiler - Coal/Wall

Control Measure Name: Low Nox Burner without Overfire Air

Rule Name: Not Applicable

Pechan Measure Code: N00901

POD: 01

Application: This control is the use of low NOx burner (LNB) technology to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another.

This control applies to wall fired (coal) utility boilers

Affected SCC:

10100202 Electric Generation, Pulverized-Dry Bottom (Bituminous Coal)

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 41% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The cost equations used in this analysis are based on cost equations from EPA's IPM (EPA, 1998). In the IPM, model plants applying LNB had capacities of 300 MW. The equations were scaled to develop costs for smaller or larger boilers than the model plant. The cost equations also assume a capacity utilization factor of 85% for the utility boilers, as well as a 7% discount rate and 15-year lifetime of the controls.

Capital Costs (CC):

Nameplate Capacity: netdc [=] MW

Total Capital Costs: TCC = \$26.70 per kW

Scaling Factor: SF = (sfn / netdc)^{sfe} = (300 / MW)^{0.359}

CC (for netdc < 500) = TCC * netdc * 1000 * SF

CC (for netdc > 500) = TCC * netdc * 1000

Operating & Maintenance (O&M):

Fixed O&M: omf = \$0.26 per kW per year

Variable O&M: omv = \$0.05 mills per kW-hr

Capacity Factor: capfac = 0.85

O&M = (omf * netdc * 1000) + (omv * netdc * 1000 * capfac * 8760 / 1000)

Equipment Life in Years = Equiplife

AT-A-GLANCE TABLE FOR UTILITY SOURCES

Interest Rate = i

Capital Recovery Factor: $CRF = [i(1+i)^{\text{Equiplife}}] / [(1+i)^{\text{Equiplife}} - 1]$

Total Cost = $(CRF * CC) + O\&M$

O&M Cost Components: With the retrofit of combustion controls, the boiler unburned carbon may increase. This increase results in a reduction in boiler efficiency, requiring more coal to be burned to maintain the boiler output. As the coal firing rate increases, there are corresponding increases in the solid waste generation and auxiliary power usage. The O&M costs were evaluated for tangential-fired boilers only. With no changes in the capital cost for wall-fired boilers, the fixed O&M costs, generally taken as a function of the capital cost, are not expected to vary. Also, no changes in the variable O&M costs are expected, since unburned carbon assumptions are unchanged.

For tangential-fired boilers, the general maintenance cost was conservatively taken as 1.5 percent of the total project cost for each technology. Also, a plant capacity factor of 85 percent was assumed.

Coal Cost: \$1.20/MMBtu

Solid waste disposal: \$12/ton

Auxiliary power: 25 mills/KWh

Note: All costs are in 1999 dollars.

Cost Effectiveness: Cost effectiveness is variable and based on plant size (nameplate capacity in MW) and the following factors: the total capital cost of \$17.26 per kW; the fixed O&M costs of \$0.26 per kW per year; and variable O&M costs of \$0.05 mills per kW per year (1999\$).

Comments:

Status: Demonstrated

Last Reviewed:

Additional Information:

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNBs create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNBs create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

References:

EPA, 2004: U.S. Environmental Protection Agency, Clean Air Market Division, "Updating Performance and Cost of Nox Control Technologies in the Integrated Planning Model" Paper # 137

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

AT-A-GLANCE TABLE FOR UTILITY SOURCES

Source Category: Utility Boiler - Coal/Wall

Control Measure Name: Low Nox Burner with Overfire Air

Rule Name: Not Applicable

Pechan Measure Code: N00902

POD: 01

Application: This control is the use of low NOx burner (LNB) technology to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another.

This control applies to wall fired (coal) utility boilers

Affected SCC:

10100202 Electric Generation, Pulverized-Dry Bottom (Bituminous Coal)

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 56% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The cost equations used in this analysis are based on cost equations from EPA's IPM (EPA, 1998). In the IPM, model plants applying LNB had capacities of 300 MW. The equations were scaled to develop costs for smaller or larger boilers than the model plant. The cost equations also assume a capacity utilization factor of 85% for the utility boilers, as well as a 7% discount rate and 15-year lifetime of the controls.

Capital Costs (CC):

Nameplate Capacity: netdc [=] MW

Total Capital Costs: TCC = \$23.43 per kW

Scaling Factor: SF = (sfn / netdc)^{sfe} = (300 / MW)^{0.359}

CC (for netdc < 500) = TCC * netdc * 1000 * SF

CC (for netdc > 500) = TCC * netdc * 1000

Operating & Maintenance (O&M):

Fixed O&M: omf = \$0.36 per kW per year

Variable O&M: omv = \$0.07 mills per kW-hr

Capacity Factor: capfac = 0.85

O&M = (omf * netdc * 1000) + (omv * netdc * 1000 * capfac * 8760 / 1000)

Equipment Life in Years = Equiplife

AT-A-GLANCE TABLE FOR UTILITY SOURCES

Interest Rate = i

Capital Recovery Factor: $CRF = [i(1+i)^{\text{Equiplife}}] / [(1+i)^{\text{Equiplife}} - 1]$

Total Cost = $(CRF * CC) + O\&M$

O&M Cost Components: With the retrofit of combustion controls, the boiler unburned carbon may increase. This increase results in a reduction in boiler efficiency, requiring more coal to be burned to maintain the boiler output. As the coal firing rate increases, there are corresponding increases in the solid waste generation and auxiliary power usage. The O&M costs were evaluated for tangential-fired boilers only. With no changes in the capital cost for wall-fired boilers, the fixed O&M costs, generally taken as a function of the capital cost, are not expected to vary. Also, no changes in the variable O&M costs are expected, since unburned carbon assumptions are unchanged.

For tangential-fired boilers, the general maintenance cost was conservatively taken as 1.5 percent of the total project cost for each technology. Also, a plant capacity factor of 85 percent was assumed.

Coal Cost: \$1.20/MMBtu

Solid waste disposal: \$12/ton

Auxiliary power: 25 mills/KWh

Note: All costs are in 1999 dollars.

Cost Effectiveness: Cost effectiveness is variable and based on plant size (nameplate capacity in MW) and the following factors: the total capital cost of \$23.43 per kW; the fixed O&M costs of \$0.36 per kW per year; and variable O&M costs of \$0.07 mills per kW per year (1999\$).

Comments:

Status: Demonstrated

Last Reviewed: 2005

Additional Information:

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNBs create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNBs create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

References:

EPA, 2004: U.S. Environmental Protection Agency, Clean Air Market Division, "Updating Performance and Cost of Nox Control Technologies in the Integrated Planning Model" Paper # 137

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

AT-A-GLANCE TABLE FOR UTILITY SOURCES

Source Category: Utility Boiler - Coal/Wall

Control Measure Name: Low Nox Burner without Overfire Air

Rule Name: Not Applicable

Pechan Measure Code: N00906

POD: 09

Application: This control is the use of low NOx burner (LNB) technology to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another.

This control applies to wall fired (coal) utility boilers

Affected SCC:

10100222 Electric Generation, Pulverized Coal: Dry Bottom (Subbituminous Coal)

10100301 Electric Generation, Pulverized Coal: Dry Bottom, Wall Fired (Lignite Coal)

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 40% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The cost equations used in this analysis are based on cost equations from EPA's IPM (EPA, 1998). In the IPM, model plants applying LNB had capacities of 300 MW. The equations were scaled to develop costs for smaller or larger boilers than the model plant. The cost equations also assume a capacity utilization factor of 85% for the utility boilers, as well as a 7% discount rate and 15-year lifetime of the controls.

Capital Costs (CC):

Nameplate Capacity: netdc [=] MW

Total Capital Costs: TCC = \$26.70 per kW

Scaling Factor: SF = (sfn / netdc)^{sfe} = (300 / MW)^{0.359}

CC (for netdc < 500) = TCC * netdc * 1000 * SF

CC (for netdc > 500) = TCC * netdc * 1000

Operating & Maintenance (O&M):

Fixed O&M: omf = \$0.26 per kW per year

Variable O&M: omv = \$0.05 mills per kW-hr

Capacity Factor: capfac = 0.85

O&M = (omf * netdc * 1000) + (omv * netdc * 1000 * capfac * 8760 / 1000)

Equipment Life in Years = Equiplife

AT-A-GLANCE TABLE FOR UTILITY SOURCES

Interest Rate = i

Capital Recovery Factor: $CRF = [i(1+i)^{\text{Equiplife}}] / [(1+i)^{\text{Equiplife}} - 1]$

Total Cost = $(CRF * CC) + O\&M$

O&M Cost Components: With the retrofit of combustion controls, the boiler unburned carbon may increase. This increase results in a reduction in boiler efficiency, requiring more coal to be burned to maintain the boiler output. As the coal firing rate increases, there are corresponding increases in the solid waste generation and auxiliary power usage. The O&M costs were evaluated for tangential-fired boilers only. With no changes in the capital cost for wall-fired boilers, the fixed O&M costs, generally taken as a function of the capital cost, are not expected to vary. Also, no changes in the variable O&M costs are expected, since unburned carbon assumptions are unchanged.

For tangential-fired boilers, the general maintenance cost was conservatively taken as 1.5 percent of the total project cost for each technology. Also, a plant capacity factor of 85 percent was assumed.

Coal Cost: \$1.20/MMBtu

Solid waste disposal: \$12/ton

Auxiliary power: 25 mills/KWh

Note: All costs are in 1999 dollars.

Cost Effectiveness: Cost effectiveness is variable and based on plant size (nameplate capacity in MW) and the following factors: the total capital cost of \$17.26 per kW; the fixed O&M costs of \$0.26 per kW per year; and variable O&M costs of \$0.05 mills per kW per year (1999\$).

Comments:

Status: Demonstrated

Last Reviewed: 2005

Additional Information:

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNBs create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNBs create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

References:

EPA, 2004: U.S. Environmental Protection Agency, Clean Air Market Division, "Updating Performance and Cost of Nox Control Technologies in the Integrated Planning Model" Paper # 137

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

AT-A-GLANCE TABLE FOR UTILITY SOURCES

Source Category: Utility Boiler - Coal/Wall

Control Measure Name: Low Nox Burner with Overfire Air

Rule Name: Not Applicable

Pechan Measure Code: N00907

POD: 09

Application: This control is the use of low NOx burner (LNB) technology to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another.

This control applies to wall fired (coal) utility boilers

Affected SCC:

10100222 Pulverized Coal: Dry Bottom (Subbituminous Coal)

10100301 Pulverized Coal: Dry Bottom, Wall Fired (Lignite Coal)

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 55% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The cost equations used in this analysis are based on cost equations from EPA's IPM (EPA, 1998). In the IPM, model plants applying LNB had capacities of 300 MW. The equations were scaled to develop costs for smaller or larger boilers than the model plant. The cost equations also assume a capacity utilization factor of 85% for the utility boilers, as well as a 7% discount rate and 15-year lifetime of the controls.

Capital Costs (CC):

Nameplate Capacity: netdc [=] MW

Total Capital Costs: TCC = \$23.43 per kW

Scaling Factor: SF = (sfn / netdc)^{sfe} = (300 / MW)^{0.359}

CC (for netdc < 500) = TCC * netdc * 1000 * SF

CC (for netdc > 500) = TCC * netdc * 1000

Operating & Maintenance (O&M):

Fixed O&M: omf = \$0.36 per kW per year

Variable O&M: omv = \$0.07 mills per kW-hr

Capacity Factor: capfac = 0.85

O&M = (omf * netdc * 1000) + (omv * netdc * 1000 * capfac * 8760 / 1000)

Equipment Life in Years = Equiplife

AT-A-GLANCE TABLE FOR UTILITY SOURCES

Interest Rate = i

Capital Recovery Factor: $CRF = [i(1+i)^{\text{Equiplife}}] / [(1+i)^{\text{Equiplife}} - 1]$

Total Cost = $(CRF * CC) + O\&M$

O&M Cost Components: With the retrofit of combustion controls, the boiler unburned carbon may increase. This increase results in a reduction in boiler efficiency, requiring more coal to be burned to maintain the boiler output. As the coal firing rate increases, there are corresponding increases in the solid waste generation and auxiliary power usage. The O&M costs were evaluated for tangential-fired boilers only. With no changes in the capital cost for wall-fired boilers, the fixed O&M costs, generally taken as a function of the capital cost, are not expected to vary. Also, no changes in the variable O&M costs are expected, since unburned carbon assumptions are unchanged.

For tangential-fired boilers, the general maintenance cost was conservatively taken as 1.5 percent of the total project cost for each technology. Also, a plant capacity factor of 85 percent was assumed.

Coal Cost: \$1.20/MMBtu

Solid waste disposal: \$12/ton

Auxiliary power: 25 mills/KWh

Note: All costs are in 1999 dollars.

Cost Effectiveness: Cost effectiveness is variable and based on plant size (nameplate capacity in MW) and the following factors: the total capital cost of \$23.43 per kW; the fixed O&M costs of \$0.36 per kW per year; and variable O&M costs of \$0.07 mills per kW per year (1999\$).

Comments:

Status: Demonstrated

Last Reviewed: 2005

Additional Information:

LNBs are designed to "stage" combustion so that two combustion zones are created, one fuel-rich combustion and one at a lower temperature. Staging techniques are usually used by LNB to supply excess air to cool the combustion process or to reduce available oxygen in the flame zone. Staged-air LNBs create a fuel-rich reducing primary combustion zone and a fuel-lean secondary combustion zone. Staged-fuel LNBs create a lean combustion zone that is relatively cool due to the presence of excess air, which acts as a heat sink to lower combustion temperatures (EPA, 2002).

References:

EPA, 2004: U.S. Environmental Protection Agency, Clean Air Market Division, "Updating Performance and Cost of Nox Control Technologies in the Integrated Planning Model" Paper # 137

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

AT-A-GLANCE TABLE FOR UTILITY SOURCES

Source Category: Utility Boiler - Cyclone

Control Measure Name: Selective Non-Catalytic Reduction (SNCR)

Rule Name: Not Applicable

Pechan Measure Code: N00701

POD: 07

Application: This control is the use of selective non-catalytic reduction add-on controls to cyclone utility boilers to reduce NOx emissions. SNCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NOx) with a nitrogen based reducing reagent, such as ammonia or urea, to reduce the NOx into molecular nitrogen (N2) and water vapor (H2O)

This control applies to bituminous/subbituminous coal-fired electricity generation sources with cyclone furnaces.

Affected SCC:

10100203 Electric Generation, Bituminous/Subbituminous Coal, Cyclone Furnace (Bituminous)

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 35% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The cost equations used in this analysis are based on cost equations from EPA's IPM (EPA, 1998). In the IPM, model plants applying SNCR had capacities of 100 MW. The equations were scaled to develop costs for smaller or larger boilers than the model plant. The cost equations also assume a high NOx rate (≥ 0.5 pounds per MMBtu) and a capacity utilization factor of 65% were assumed for the utility boilers, as well as a 7% discount rate and 20-year lifetime of the controls.

Control Costs (CC):

Nameplate Capacity: netdc [=] MW

Total Capital Costs: TCC = \$8.00 per kW

Scaling Factor: SF = (sfn / netdc)^{sfe} = (100 / MW)^{0.577}

CC (for netdc < 500) = TCC * netdc * 1000 * SF

CC (for netdc > 500) = TCC * netdc * 1000

Operating & Maintenance (O&M):

Fixed O&M: omf = \$0.12 per kW per year

Variable O&M: omv = \$1.05 mills per kW-hr

Capacity Factor: capfac = 0.65

AT-A-GLANCE TABLE FOR UTILITY SOURCES

$$\text{O\&M} = (\text{omf} * \text{netdc} * 1000) + (\text{omv} * \text{netdc} * 1000 * \text{capfac} * 8760 / 1000)$$

$$\text{Equipment Life in Years} = \text{Equiplife}$$

$$\text{Interest Rate} = i$$

$$\text{Capital Recovery Factor: CRF} = [i (1 + i)^{\text{Equiplife}}] / [(1 + i)^{\text{Equiplife}} - 1]$$

$$\text{Total Cost} = (\text{CRF} * \text{CC}) + \text{O\&M}$$

Note: All costs are in 1990 dollars.

Cost Effectiveness: Cost effectiveness is variable and based on plant size (nameplate capacity in MW) and the following factors: the total capital cost is \$8.00 per kW; the fixed O&M cost is \$0.12 per kW per year; and the variable O&M cost is \$1.05 mills per kW-hr (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

SNCR is the reduction of NO_x in flue gas to N₂ and water vapor. This reduction is done with a nitrogen based reducing reagent, such as ammonia or urea. The reagent can react with a number of flue gas components. However, the NO_x reduction reaction is favored for a specific temperature range and in the presence of oxygen (EPA, 2002).

Both ammonia and urea are used as reagents. The cost of the reagent represents a large part of the annual costs of an SNCR system. Ammonia is generally less expensive than urea. However, the choice of reagent is also based on physical properties and operational considerations (EPA, 2002).

References:

EPA, 1998: U.S. Environmental Protection Agency, Office of Air and Radiation, "Analyzing Electric Power Generation Under the CAAA," Washington, DC, March 1998.

AT-A-GLANCE TABLE FOR UTILITY SOURCES

Source Category: Utility Boiler - Cyclone

Control Measure Name: Natural Gas Reburn (NGR)

Rule Name: Not Applicable

Pechan Measure Code: N00702

POD: 07

Application: Natural gas reburning (NGR) involves add-on controls to reduce NO_x emissions. NGR is a combustion control technology in which part of the main fuel heat input is diverted to locations above the main burners, called the reburn zone. As flue gas passes through the reburn zone, a portion of the NO_x formed in the main combustion zone is reduced by hydrocarbon radicals and converted to molecular nitrogen (N₂).

This control applies to pulverized-dry bottom coal-fired electricity generation sources with cyclone furnaces.

Applies to bituminous/subbituminous coal-fired electricity generation sources with cyclone furnaces.

Affected SCC:

10100203 Electric Generation, Bituminous/Subbituminous Coal, Cyclone Furnace (Bituminous)

Pollutant(s)	PM10	PM2.5	EC	OC	NO _x	VOC	SO ₂	NH ₃	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 50% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The cost equations used in this analysis are based on cost equations from EPA's IPM (EPA, 1998). In the IPM, model plants applying NGR had capacities of 200 MW. The equations were scaled to develop costs for smaller or larger boilers than the model plant. The cost equations also assume a high NO_x rate (≥ 0.5 pounds per MMBtu), a 7% discount rate, and a 20-year lifetime of the controls.

Capital Costs (CC):

Nameplate Capacity: netdc [=] MW

Total Capital Costs: TCC = \$26.90 per kW

Scaling Factor: SF = (sfn / netdc)^{sfe} = (200 / MW)^{0.35}

CC (for netdc < 500) = TCC * netdc * 1000 * SF

CC (for netdc > 500) = TCC * netdc * 1000

Operating & Maintenance (O&M):

Fixed O&M: omf = \$0.41 per kW per year

Variable O&M: omv = \$0 millions per kW-hr

AT-A-GLANCE TABLE FOR UTILITY SOURCES

Capacity Utilization Factor: $\text{capfac} = 0.65$

O&M Cost Components: The O&M cost breakdown is estimated using the economic analysis for a 200 megawatt unit provided in Appendix E: Cost Analysis of Reburning Systems for conventional gas reburn. The example calculation with a \$1.00 per million Btu difference between the primary fuel cost and the reburn fuel cost was used. The reference for this information is the 1998 Andover Technology Partners report for NESCAUM/MARAMA. The fuel cost differential is the dominant operating cost of NGR.

Coal Cost: \$1.50/MMBtu

Natural Gas Cost: \$2.50/MMBtu

$$\text{O\&M} = (\text{omf} * \text{netdc} * 1000) + (\text{omv} * \text{netdc} * 1000 * \text{capfac} * 8760 / 1000)$$

Equipment Life in Years = Equiplife

Interest Rate = i

$$\text{Capital Recovery Factor: CRF} = [i(1+i)^{\text{Equiplife}}] / [(1+i)^{\text{Equiplife}} - 1]$$

$$\text{Total Cost} = (\text{CRF} * \text{CC}) + \text{O\&M}$$

Note: All costs are in 1990 dollars.

Cost Effectiveness: Cost effectiveness is variable and based on plant size (nameplate capacity in MW) and the following factors: the total capital cost of \$26.90 per kW, the fixed O&M of \$0.41 per kW per year, and the variable O&M of \$0 per kW-hr (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

In a reburn boiler, fuel is injected into the upper furnace region to convert the NO_x formed in the primary combustion zone to molecular N₂ and H₂O. In general, the overall process occurs within three zones of the boiler; the combustion zone, the gas reburning zone, and the burnout zone (ERG, 2000). In the combustion zone the amount of fuel is reduced and the burners may be operated at the lowest excess air level. In the gas reburning zone the fuel not used in the combustion zone is injected to create a fuel-rich region where radicals can react with NO_x to form molecular Nitrogen. In the burnout zone a separate overfire air system redirects air from the primary combustion zone to ensure complete combustion of unreacted fuel leaving the reburning zone.

Operational parameters that affect the performance of reburn include reburn zone stoichiometry, residence time in the reburn zone, reburn fuel carrier gas and temperature and O₂ levels in the burnout zone (ERG, 2000).

References:

EPA, 1998: U.S. Environmental Protection Agency, Office of Air and Radiation, "Analyzing Electric Power Generation Under the CAAA," Washington, DC, March 1998.

ERG, 2000: Eastern Research Group, Inc., "How to Incorporate the Effects of Air Pollution Control Device Efficiencies and Malfunctions into Emission Inventory Estimates," prepared for Emission Inventory Improvement Program, Point Sources Committee, July 2000.

AT-A-GLANCE TABLE FOR UTILITY SOURCES

Staudt, 1998: Staudt, James E., "Status Report on NOx Control Technologies and Cost Effectiveness for Utility Boilers," Andover Technology Partners, North Andover, MA, prepared for NESCAUM and MARAMA, June 1998.

AT-A-GLANCE TABLE FOR UTILITY SOURCES

Source Category: Utility Boiler - Cyclone

Control Measure Name: Selective Catalytic Reduction (SCR)

Rule Name: Not Applicable

Pechan Measure Code: N00703

POD: 07

Application: This control reduces NOx emissions using selective catalytic add-on controls on utility boilers with cyclone burners. SCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NOx) with a nitrogen based reducing reagent, such as ammonia or urea, to reduce the NOx into molecular nitrogen (N2) and water vapor (H2O). The SCR utilizes a catalyst to increase the NOx removal efficiency, which allows the process to occur at lower temperatures.

This control applies to bituminous/subbituminous coal-fired electricity generation sources with cyclone furnaces.

Affected SCC:

10100203 Electric Generation, Bituminous/Subbituminous Coal, Cyclone Furnace (Bituminous)

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 80% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The cost equations used in this analysis are based on cost equations from EPA's IPM (EPA, 1998). In the IPM, model plants applying SCR had capacities of 200 MW. The equations were scaled to develop costs for smaller or larger boilers than the model plant. The cost equations also assume a high NOx rate (≥ 0.5 pounds per MMBtu) and a capacity utilization factor of 65% were assumed for the utility boilers, as well as a 7% discount rate and 20-year lifetime of the controls.

Capital Costs (CC):

Nameplate Capacity: $\text{netdc} [=]$ MW

Total Capital Costs: $\text{TCC} = \$80 \text{ per kW}$

Scaling Factor: $\text{SF} = (\text{sfn} / \text{netdc})^{\text{sfe}} = (200 / \text{MW})^{0.35}$

$\text{CC (for netdc} < 500) = \text{TCC} * \text{netdc} * 1000 * \text{SF}$

$\text{CC (for netdc} > 500) = \text{TCC} * \text{netdc} * 1000$

Operating & Maintenance (O&M):

Fixed O&M: $\text{omf} = \$0.53 \text{ per kW per year}$

Variable O&M: $\text{omv} = \$0.37 \text{ mills per kW-hr}$

Capacity Factor: $\text{capfac} = 0.65$

AT-A-GLANCE TABLE FOR UTILITY SOURCES

$$\text{O\&M} = (\text{omf} * \text{netdc} * 1000) + (\text{omv} * \text{netdc} * 1000 * \text{capfac} * 8760 / 1000)$$

Equipment Life in Years = Equiplife

Interest Rate = i

$$\text{Capital Recovery Factor: CRF} = [i (1 + i)^{\text{Equiplife}}] / [(1 + i)^{\text{Equiplife}} - 1]$$

$$\text{Total Cost} = (\text{CRF} * \text{CC}) + \text{O\&M}$$

O&M Cost Components: The O&M cost breakdown is estimated using the Chapter 4 costing algorithms in EPA, 2001. The fixed O&M cost is the sum of the annual maintenance material and labor cost, and is estimated to be 0.66 percent of the capital cost. This portion of the O&M cost is included in the database as maintenance labor. The NH₃ use cost equation is used to estimate chemicals costs. The annual replacement cost equation is used to estimate replacement materials costs. The energy requirement cost equation is used to estimate electricity costs.

Electricity cost = \$0.03/kWhr

Ammonia cost = \$225/ton

The above O&M component costs are in 2000 dollars. The model plant size used to estimate utility boiler O&M cost components is 750 MMBtu/hour.

Note: All costs are in 1999 dollars.

Cost Effectiveness: Cost effectiveness is variable and based on plant size (nameplate capacity in MW) and the following factors: the total capital cost of \$80 per kW; the fixed O&M cost of \$0.53 per kW per year; and the variable O&M cost of \$0.37 mills per KW-hr (1999\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

Like SNCR, SCR is based on the chemical reduction of the NO_x molecule. The primary difference between SNCR and SCR is that SCR uses a metal-based catalyst to increase the rate of reaction (EPA, 2002). A nitrogen based reducing reagent, such as ammonia or urea, is injected into the flue gas. The reagent reacts selectively with the flue gas NO_x within a specific temperature range and in the presence of the catalyst and oxygen to reduce the NO_x.

References:

EPA, 1998: U.S. Environmental Protection Agency, Office of Air and Radiation, "Analyzing Electric Power Generation Under the CAAA," Washington, DC, March 1998.

EPA, 2001: U.S. Environmental Protection, Office of Research and Development, "Cost of Selective Catalytic Reduction (SCR) Application for NO_x Control on Coal-Fired Boilers," EPA-600/R-01-087, Research Triangle Park, NC, October 2001.

AT-A-GLANCE TABLE FOR UTILITY SOURCES

Source Category: Utility Boiler - Oil-Gas/Tangential

Control Measure Name: Selective Non-Catalytic Reduction (SNCR)

Rule Name: Not Applicable

Pechan Measure Code: N00601

POD: 06

Application: This control reduces NOx emissions using selective non-catalytic reduction add-on controls to tangentially fired (oil/gas) utility boilers. SNCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NOx) with a nitrogen based reducing reagent, such as ammonia or urea, to reduce the NOx into molecular nitrogen (N2) and water vapor (H2O).

The control applies to tangentially natural-gas fired electricity generation sources.

Affected SCC:

10100604 Electric Generation, Natural Gas, Tangentially Fired Units

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 50% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The cost equations used in this analysis are based on cost equations from EPA's IPM (EPA, 1998). In the IPM, model plants applying SNCR had capacities of 200 MW. The equations were scaled to develop costs for smaller or larger boilers than the model plant. The cost equations also assume a high NOx rate (≥ 0.5 pounds per MMBtu) and a capacity utilization factor of 65% were assumed for the utility boilers, as well as a 7% discount rate and 20-year lifetime.

Control Costs (CC):

Nameplate Capacity: netdc [=] MW

Total Capital Costs: TCC = \$7.80 per kW

Scaling Factor: SF = (sfn / netdc)^{sfe} = (200 / MW)^{0.577}

CC (for netdc < 500) = TCC * netdc * 1000 * SF

CC (for netdc > 500) = TCC * netdc * 1000

Operating & Maintenance (O&M):

Fixed O&M: omf = \$0.12 per kW per year

Variable O&M: omv = \$0.37 mills per kW-hr

Capacity Factor: capfac = 0.65

O&M = (omf * netdc * 1000) + (omv * netdc * 1000 * capfac * 8760 / 1000)

AT-A-GLANCE TABLE FOR UTILITY SOURCES

Equipment Life in Years = Equiplife

Interest Rate = i

Capital Recovery Factor: $CRF = [i(1+i)^{\text{Equiplife}}] / [(1+i)^{\text{Equiplife}} - 1]$

Total Cost = $(CRF * TCC) + O\&M$

Note: All costs are in 1990 dollars.

Cost Effectiveness: Cost effectiveness is variable and based on plant size (nameplate capacity in MW) and the following factors: the total capital costs of \$7.80 per kW; the fixed O&M cost of \$0.12 per kW per year; and the variable O&M cost of \$0.37 mills per kW-hr (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

SNCR is the reduction of NO_x in flue gas to N₂ and water vapor. This reduction is done with a nitrogen based reducing reagent, such as ammonia or urea. The reagent can react with a number of flue gas components. However, the NO_x reduction reaction is favored for a specific temperature range and in the presence of oxygen (EPA, 2002).

Both ammonia and urea are used as reagents. The cost of the reagent represents a large part of the annual costs of an SNCR system. Ammonia is generally less expensive than urea. However, the choice of reagent is also based on physical properties and operational considerations (EPA, 2002).

References:

EPA, 1998: U.S. Environmental Protection Agency, Office of Air and Radiation, "Analyzing Electric Power Generation Under the CAAA," Washington, DC, March 1998.

AT-A-GLANCE TABLE FOR UTILITY SOURCES

Source Category: Utility Boiler - Oil-Gas/Tangential

Control Measure Name: Natural Gas Reburn (NGR)

Rule Name: Not Applicable

Pechan Measure Code: N00602

POD: 06

Application: Natural gas reburning (NGR) involves add-on controls to reduce NOx emissions. NGR is a combustion control technology in which part of the main fuel heat input is diverted to locations above the main burners, called the reburn zone. As flue gas passes through the reburn zone, a portion of the NOx formed in the main combustion zone is reduced by hydrocarbon radicals and converted to molecular nitrogen (N2).

This control applies to tangentially natural-gas fired electricity generation sources.

Affected SCC:

10100604 Electric Generation, Natural Gas, Tangentially Fired Units

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 50% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The cost equations used in this analysis are based on cost equations from EPA's IPM (EPA, 1998). In the IPM, model plants applying NGR had capacities of 200 MW. The equations were scaled to develop costs for smaller or larger boilers than the model plant. The cost equations also assume a high NOx rate (≥ 0.5 pounds per MMBtu) and a capacity utilization factor of 65% were assumed for the utility boilers, as well as a 7% discount rate and 20-year lifetime of the controls.

Capital Costs (CC):

Nameplate Capacity: netdc [=] MW

Total Capital Costs: TCC = \$16.40 per kW

Scaling Factor: SF = $(\text{sfn} / \text{netdc})^{\text{sfe}} = (200 / \text{MW})^{0.35}$

CC (for netdc < 500) = TCC * netdc * 1000 * SF

CC (for netdc > 500) = TCC * netdc * 1000

Operating & Maintenance (O&M):

Fixed O&M: omf = \$0.25 per kW per year

Variable O&M: omv = \$0.02 mills per kW-hr

Capacity Factor: capfac = 0.65

O&M = (omf * netdc * 1000) + (omv * netdc * 1000 * capfac * 8760 / 1000)

AT-A-GLANCE TABLE FOR UTILITY SOURCES

O&M Cost Components: The O&M cost breakdown is estimated using the economic analysis for a 200 megawatt unit provided in Appendix E: Cost Analysis of Reburning Systems for conventional gas reburn. The example calculation with a \$1.00 per million Btu difference between the primary fuel cost and the reburn fuel cost was used. The reference for this information is the 1998 Andover Technology Partners report for NESCAUM/MARAMA. The fuel cost differential is the dominant operating cost of NGR.

Coal Cost: \$1.50/MMBtu

Natural Gas Cost: \$2.50/MMBtu

Equipment Life in Years = Equiplife

Interest Rate = i

Capital Recovery Factor: $CRF = [i(1+i)^{Equiplife}] / [(1+i)^{Equiplife} - 1]$

Total Cost = $(CRF * CC) + O\&M$

Cost Effectiveness: Cost effectiveness is variable and based on plant size (nameplate capacity in MW) and the following factors: the total capital cost of \$16.40 per kW, the fixed O&M of \$0.25 per kW per year, and the variable O&M of \$0.02 mills per kW-hr (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

In a reburn boiler, fuel is injected into the upper furnace region to convert the NO_x formed in the primary combustion zone to molecular N₂ and H₂O. In general, the overall process occurs within three zones of the boiler; the combustion zone, the gas reburning zone, and the burnout zone (ERG, 2000). In the combustion zone the amount of fuel is reduced and the burners may be operated at the lowest excess air level. In the gas reburning zone the fuel not used in the combustion zone is injected to create a fuel-rich region where radicals can react with NO_x to form molecular Nitrogen. In the burnout zone a separate overfire air system redirects air from the primary combustion zone to ensure complete combustion of unreacted fuel leaving the reburning zone.

Operational parameters that affect the performance of reburn include reburn zone stoichiometry, residence time in the reburn zone, reburn fuel carrier gas and temperature and O₂ levels in the burnout zone (ERG, 2000).

References:

EPA, 1998: U.S. Environmental Protection Agency, Office of Air and Radiation, "Analyzing Electric Power Generation Under the CAAA," Washington, DC, March 1998.

ERG, 2000: Eastern Research Group, Inc., "How to Incorporate the Effects of Air Pollution Control Device Efficiencies and Malfunctions into Emission Inventory Estimates," prepared for Emission Inventory Improvement Program, Point Sources Committee, July 2000.

Staudt, 1998: Staudt, James E., "Status Report on NO_x Control Technologies and Cost Effectiveness for Utility Boilers," Andover Technology Partners, North Andover, MA, prepared for NESCAUM and MARAMA, June 1998.

AT-A-GLANCE TABLE FOR UTILITY SOURCES

Source Category: Utility Boiler - Oil-Gas/Tangential

Control Measure Name: Selective Catalytic Reduction (SCR)

Rule Name: Not Applicable

Pechan Measure Code: N00603

POD: 06

Application: This control is the selective catalytic reduction of NOx through add-on controls to tangentially fired (oil/gas) utility boilers. SCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NOx) with a nitrogen based reducing reagent, such as ammonia or urea, to reduce the NOx into molecular nitrogen (N2) and water vapor (H2O). The SCR utilizes a catalyst to increase the NOx removal efficiency, which allows the process to occur at lower temperatures.

This control applies to tangentially natural-gas fired electricity generation sources.

Affected SCC:

10100604 Electric Generation, Natural Gas, Tangentially Fired Units

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 80% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The cost equations used in this analysis are based on cost equations from EPA's IPM (EPA, 1998). In the IPM, model plants applying SCR had capacities of 200 MW. The equations were scaled to develop costs for smaller or larger boilers than the model plant. The cost equations also assume a high NOx rate (≥ 0.5 pounds per MMBtu) and a capacity utilization factor of 65% were assumed for the utility boilers, as well as a 7% discount rate and 20-year lifetime of the controls.

Capital Costs (CC):

Nameplate Capacity: $\text{netdc} [=] \text{MW}$

Total Capital Costs: $\text{TCC} = \$23.30 \text{ per kW}$

Scaling Factor: $\text{SF} = (\text{sfn} / \text{netdc})^{\text{sfe}} = (200 / \text{MW})^{0.35}$

$\text{CC (for netdc} < 500) = \text{TCC} * \text{netdc} * 1000 * \text{SF}$

$\text{CC (for netdc} > 500) = \text{TCC} * \text{netdc} * 1000$

Operating & Maintenance (O&M):

Fixed O&M: $\text{omf} = \$0.72 \text{ per kW per year}$

Variable O&M: $\text{omv} = \$0.08 \text{ mills per kW-hr}$

Capacity Factor: $\text{capfac} = 0.65$

AT-A-GLANCE TABLE FOR UTILITY SOURCES

$$\text{O\&M} = (\text{omf} * \text{netdc} * 1000) + (\text{omv} * \text{netdc} * 1000 * \text{capfac} * 8760 / 1000)$$

$$\text{Equipment Life in Years} = \text{Equiplife}$$

$$\text{Interest Rate} = i$$

$$\text{Capital Recovery Factor: CRF} = [i (1 + i)^{\text{Equiplife}}] / [(1 + i)^{\text{Equiplife}} - 1]$$

$$\text{Total Cost} = (\text{CRF} * \text{CC}) + \text{O\&M}$$

Note: All costs are in 1990 dollars.

Cost Effectiveness: Cost effectiveness is variable and based on plant size (nameplate capacity in MW) and the following factors: the total capital cost of \$23.30 per kW; the fixed O&M cost of \$0.72 per kW per year; and the variable O&M cost of \$0.08 mills per kW-hr (1990\$).

Comments:

Status: Demonstrated	Last Reviewed: 2001
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Additional Information:

Like SNCR, SCR is based on the chemical reduction of the NO_x molecule. The primary difference between SNCR and SCR is that SCR uses a metal-based catalyst to increase the rate of reaction (EPA, 2002). A nitrogen based reducing reagent, such as ammonia or urea, is injected into the flue gas. The reagent reacts selectively with the flue gas NO_x within a specific temperature range and in the presence of the catalyst and oxygen to reduce the NO_x.

References:

EPA, 1998: U.S. Environmental Protection Agency, Office of Air and Radiation, "Analyzing Electric Power Generation Under the CAAA," Washington, DC, March 1998.

AT-A-GLANCE TABLE FOR UTILITY SOURCES

Source Category: Utility Boiler - Oil-Gas/Wall

Control Measure Name: Selective Non-Catalytic Reduction (SNCR)

Rule Name: Not Applicable

Pechan Measure Code: N00501

POD: 05

Application: This control is the use of selective non-catalytic reduction add-on controls to wall fired (oil/gas) utility boilers for the reduction of NOx emissions. SNCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NOx) with a nitrogen based reducing reagent, such as ammonia or urea, to reduce the NOx into molecular nitrogen (N2) and water vapor (H2O).

The control applies to large (>100 million Btu/hr) natural-gas fired electricity generation sources, excluding tangentially fired sources.

Affected SCC:

10100601 Electric Generation, Natural Gas, Boilers > 100 Million Btu/hr except Tangential

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 50% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The cost equations used in this analysis are based on cost equations from EPA's IPM (EPA, 1998). In the IPM, model plants applying SNCR had capacities of 200 MW. The equations were scaled to develop costs for smaller or larger boilers than the model plant. The cost equations also assume a high NOx rate (≥ 0.5 pounds per MMBtu) and a capacity utilization factor of 65% were assumed for the utility boilers, as well as a 7% discount rate and 20-year lifetime.

Control Costs (CC):

Nameplate Capacity: $\text{netdc} [=] \text{MW}$

Total Capital Costs: $\text{TCC} = \$7.80 \text{ per kW}$

Scaling Factor: $\text{SF} = (\text{sfn} / \text{netdc})^{\text{sfe}} = (200 / \text{MW})^{0.577}$

$\text{CC (for netdc} < 500) = \text{TCC} * \text{netdc} * 1000 * \text{SF}$

$\text{CC (for netdc} > 500) = \text{TCC} * \text{netdc} * 1000$

Operating & Maintenance (O&M):

Fixed O&M: $\text{omf} = \$0.12 \text{ per kW per year}$

Variable O&M: $\text{omv} = \$0.37 \text{ mills per kW-hr}$

Capacity Factor: $\text{capfac} = 0.65$

AT-A-GLANCE TABLE FOR UTILITY SOURCES

$$\text{O\&M} = (\text{omf} * \text{netdc} * 1000) + (\text{omv} * \text{netdc} * 1000 * \text{capfac} * 8760 / 1000)$$

$$\text{Equipment Life in Years} = \text{Equiplife}$$

$$\text{Interest Rate} = i$$

$$\text{Capital Recovery Factor: CRF} = [i (1 + i)^{\text{Equiplife}}] / [(1 + i)^{\text{Equiplife}} - 1]$$

$$\text{Total Cost} = (\text{CRF} * \text{TCC}) + \text{O\&M}$$

Note: All costs are in 1990 dollars.

Cost Effectiveness: Cost effectiveness is variable and based on plant size (nameplate capacity in MW) and the following factors: the total capital costs of \$7.80 per kW; the fixed O&M cost of \$0.12 per kW per year; and the variable O&M cost of \$0.37 mills per kW-hr (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

SNCR is the reduction of NO_x in flue gas to N₂ and water vapor. This reduction is done with a nitrogen based reducing reagent, such as ammonia or urea. The reagent can react with a number of flue gas components. However, the NO_x reduction reaction is favored for a specific temperature range and in the presence of oxygen (EPA, 2002).

Both ammonia and urea are used as reagents. The cost of the reagent represents a large part of the annual costs of an SNCR system. Ammonia is generally less expensive than urea. However, the choice of reagent is also based on physical properties and operational considerations (EPA, 2002).

References:

EPA, 1998: U.S. Environmental Protection Agency, Office of Air and Radiation, "Analyzing Electric Power Generation Under the CAAA," Washington, DC, March 1998.

AT-A-GLANCE TABLE FOR UTILITY SOURCES

Source Category: Utility Boiler - Oil-Gas/Wall

Control Measure Name: Natural Gas Reburn (NGR)

Rule Name: Not Applicable

Pechan Measure Code: N00502

POD: 05

Application: Natural gas reburning (NGR) involves add-on controls to reduce NO_x emissions. NGR is a combustion control technology in which part of the main fuel heat input is diverted to locations above the main burners, called the reburn zone. As flue gas passes through the reburn zone, a portion of the NO_x formed in the main combustion zone is reduced by hydrocarbon radicals and converted to molecular nitrogen (N₂).

This control applies to large (>100 million Btu/hr) natural-gas fired electricity generation sources, excluding tangentially fired sources.

Affected SCC:

10100601 Electric Generation, Natural Gas, Boilers > 100 Million Btu/hr except Tangential

Pollutant(s)	PM10	PM2.5	EC	OC	NO _x	VOC	SO ₂	NH ₃	CO	Hg
					√*					

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 50% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The cost equations used in this analysis are based on cost equations from EPA's IPM (EPA, 1998). In the IPM, model plants applying NGR had capacities of 200 MW. The equations were scaled to develop costs for smaller or larger boilers than the model plant. The cost equations also assume a high NO_x rate (≥ 0.5 pounds per MMBtu) and a capacity utilization factor of 65% were assumed for the utility boilers, as well as a 7% discount rate and 20-year lifetime of the controls.

Capital Costs (CC):

Nameplate Capacity: netdc [=] MW

Total Capital Costs: TCC = \$16.40 per kW

Scaling Factor: SF = (sfn / netdc)^{sfe} = (200 / MW)^{0.35}

CC (for netdc < 500) = TCC * netdc * 1000 * SF

CC (for netdc > 500) = TCC * netdc * 1000

Operating & Maintenance (O&M):

Fixed O&M: omf = \$0.25 per kW per year

Variable O&M: omv = \$0.02 mills per kW-hr

Capacity Factor: capfac = 0.65

AT-A-GLANCE TABLE FOR UTILITY SOURCES

$$\text{O\&M} = (\text{omf} * \text{netdc} * 1000) + (\text{omv} * \text{netdc} * 1000 * \text{capfac} * 8760 / 1000)$$

O&M Cost Components: The O&M cost breakdown is estimated using the economic analysis for a 200 megawatt unit provided in Appendix E: Cost Analysis of Reburning Systems for conventional gas reburn. The example calculation with a \$1.00 per million Btu difference between the primary fuel cost and the reburn fuel cost was used. The reference for this information is the 1998 Andover Technology Partners report for NESCAUM/MARAMA. The fuel cost differential is the dominant operating cost of NGR.

Coal Cost: \$1.50/MMBtu

Natural Gas Cost: \$2.50/MMBtu

Equipment Life in Years = Equiplife

Interest Rate = i

Capital Recovery Factor: $\text{CRF} = [i(1+i)^{\text{Equiplife}}] / [(1+i)^{\text{Equiplife}} - 1]$

Total Cost = (CRF * CC) + O&M

Cost Effectiveness: Cost effectiveness is variable and based on plant size (nameplate capacity in MW) and the following factors: the total capital cost of \$16.40 per kW, the fixed O&M of \$0.25 per kW per year, and the variable O&M of \$0.02 mills per kW-hr (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

In a reburn boiler, fuel is injected into the upper furnace region to convert the NO_x formed in the primary combustion zone to molecular N₂ and H₂O. In general, the overall process occurs within three zones of the boiler; the combustion zone, the gas reburning zone, and the burnout zone (ERG, 2000). In the combustion zone the amount of fuel is reduced and the burners may be operated at the lowest excess air level. In the gas reburning zone the fuel not used in the combustion zone is injected to create a fuel-rich region where radicals can react with NO_x to form molecular Nitrogen. In the burnout zone a separate overfire air system redirects air from the primary combustion zone to ensure complete combustion of unreacted fuel leaving the reburning zone.

Operational parameters that affect the performance of reburn include reburn zone stoichiometry, residence time in the reburn zone, reburn fuel carrier gas and temperature and O₂ levels in the burnout zone (ERG, 2000).

References:

EPA, 1998: U.S. Environmental Protection Agency, Office of Air and Radiation, "Analyzing Electric Power Generation Under the CAAA," Washington, DC, March 1998.

ERG, 2000: Eastern Research Group, Inc., "How to Incorporate the Effects of Air Pollution Control Device Efficiencies and Malfunctions into Emission Inventory Estimates," prepared for Emission Inventory Improvement Program, Point Sources Committee, July 2000.

Staudt, 1998: Staudt, James E., "Status Report on NO_x Control Technologies and Cost Effectiveness for Utility Boilers," Andover Technology Partners, North Andover, MA, prepared for NESCAUM and MARAMA, June 1998.

AT-A-GLANCE TABLE FOR UTILITY SOURCES

Source Category: Utility Boiler - Oil-Gas/Wall

Control Measure Name: Selective Catalytic Reduction (SCR)

Rule Name: Not Applicable

Pechan Measure Code: N00503

POD: 05

Application: This control is the selective catalytic reduction of NO_x through add-on controls to wall fired (oil/gas) utility boilers. SCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NO_x) with a nitrogen based reducing reagent, such as ammonia or urea, to reduce the NO_x into molecular nitrogen (N₂) and water vapor (H₂O). The SCR utilizes a catalyst to increase the NO_x removal efficiency, which allows the process to occur at lower temperatures.

Applies to large (>100 million Btu/hr) natural-gas fired electricity generation sources, excluding tangentially fired sources.

Affected SCC:

10100601 Electric Generation, Natural Gas, Boilers > 100 Million Btu/hr except Tangential

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√*			X		

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 80% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The cost equations used in this analysis are based on cost equations from EPA's IPM (EPA, 1998). In the IPM, model plants applying SCR had capacities of 200 MW. The equations were scaled to develop costs for smaller or larger boilers than the model plant. The cost equations also assume a high NO_x rate (≥ 0.5 pounds per MMBtu) and a capacity utilization factor of 65% were assumed for the utility boilers, as well as a 7% discount rate and 20-year lifetime of the controls.

Capital Costs (CC):

Nameplate Capacity: netdc [=] MW

Total Capital Costs: TCC = \$23.30 per kW

Scaling Factor: SF = (sfn / netdc)^{sfe} = (200 / MW)^{0.35}

CC (for netdc < 500) = TCC * netdc * 1000 * SF

CC (for netdc > 500) = TCC * netdc * 1000

Operating & Maintenance (O&M):

Fixed O&M: omf = \$0.72 per kW per year

Variable O&M: omv = \$0.08 mills per kW-hr

Capacity Factor: capfac = 0.65

AT-A-GLANCE TABLE FOR UTILITY SOURCES

$$\text{O\&M} = (\text{omf} * \text{netdc} * 1000) + (\text{omv} * \text{netdc} * 1000 * \text{capfac} * 8760 / 1000)$$

$$\text{Equipment Life in Years} = \text{Equiplife}$$

$$\text{Interest Rate} = i$$

$$\text{Capital Recovery Factor: CRF} = [i (1 + i)^{\text{Equiplife}}] / [(1 + i)^{\text{Equiplife}} - 1]$$

$$\text{Total Cost} = (\text{CRF} * \text{CC}) + \text{O\&M}$$

Note: All costs are in 1990 dollars.

Cost Effectiveness: Cost effectiveness is variable and based on plant size (nameplate capacity in MW) and the following factors: the total capital cost of \$23.30 per kW; the fixed O&M cost of \$0.72 per kW per year; and the variable O&M cost of \$0.08 mills per kW-hr (1990\$).

Comments:

Status: Demonstrated	Last Reviewed: 2001
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Additional Information:

Like SNCR, SCR is based on the chemical reduction of the NO_x molecule. The primary difference between SNCR and SCR is that SCR uses a metal-based catalyst to increase the rate of reaction (EPA, 2002). A nitrogen based reducing reagent, such as ammonia or urea, is injected into the flue gas. The reagent reacts selectively with the flue gas NO_x within a specific temperature range and in the presence of the catalyst and oxygen to reduce the NO_x.

References:

EPA, 1998: U.S. Environmental Protection Agency, Office of Air and Radiation, "Analyzing Electric Power Generation Under the CAAA," Washington, DC, March 1998.

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Agricultural Burning

Control Measure Name: Bale Stack/Propane Burning

Rule Name: Not Applicable

Pechan Measure Code: Pagbu

POD: N/A

Application: Two control measures applied to area source agricultural burning sources are propane and bale/stack burning. Propane flammers are an alternative to open filed burning. The bale/stack burning technique is designed to increase the fire efficiency by stacking or baling the fuel before burning. Burning in piles or stacks tends to foster more complete combustion, thereby reducing PM emissions.

This control is applicable to field burning where the entire field would be set on fire, and can be applied to all crop types. These sources are classified under 2801500000.

Affected SCC:

2801500000 Agricultural Field Burning - whole field set on fire, Total, all crop types

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: PM10 control efficiency is 49-63% from uncontrolled; PM2.5 control efficiency is 25% from uncontrolled

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The cost of using a propane burner includes the cost for physical removal of residue, and the costs for operating the flamer, which vary with the speed of operation. The average cost of propane burning is \$56 per acre, which includes the cost for residue removal and for the propane flaming (Pechan, 1998).

The costs for baling and burning average \$25 per ton of residue baled and \$0.50 per ton to burn, or approximately \$25.50 per ton of residue burned (EPA, 1992).

Capital costs for both of these techniques are assumed to be zero.

Costs vary by state and crop type. The cost effectiveness ranges from \$1,832 for Georgia to \$8,164 for Florida. The PM10 control efficiency ranges from 49% for Louisiana to 63% for Alabama, Georgia, Kansas, Mississippi, and North Carolina.

Note: All costs are in 1992 dollars.

Cost Effectiveness: The cost effectiveness per ton PM10 reduced is \$2,591. (1992\$)

Comments:

Status: Demonstrated

Last Reviewed: 1998

AT-A-GLANCE TABLE FOR AREA SOURCES

Additional Information:

References:

EPA, 1992: U.S. Environmental Protection Agency, "Prescribed Burning Background Document," Office of Air Quality Planning and Standards, Research Triangle Park, NC, September 1992.

Pechan, 1995: E.H. Pechan & Associates, Inc., "Regional Particulate Strategies - Draft Report," prepared for U.S. Environmental Protection Agency, Office of Policy Planning and Evaluation, Washington, DC, September 1995.

Pechan, 1998: E.H. Pechan & Associates, Inc., "Clean Air Act Section 812 Prospective Cost Analysis - Draft Report," prepared for Industrial Economics, Inc., Cambridge, MA, September 1998.

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Agricultural Tilling

Control Measure Name: Soil Conservation Plans

Rule Name: Soil Conservation Plans

Pechan Measure Code: Pagtl

POD: N/A

Application: The soil conservation plan measure would require farmers and farmland owners to develop soil conservation plans with the assistance of the U.S. Department of Agriculture's (USDA) Natural Resource Conservation Service. Soil conservation plans could include: establishment of rows of vegetation across the prevailing wind, cessation of tilling on high-wind days, establishment of snow (sand) fences, establishment of end-of-row turn-around areas, deep furrowing of fallow parcels, prohibition of disking and improved tillage practices.

This control applies to the SCC for agricultural tilling, 2801000003.

Affected SCC:

2801000003 Agriculture - Crops, Tilling

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: PM10 control efficiency is 12% from uncontrolled, PM2.5 control efficiency is 25% from uncontrolled

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: SCAQMD estimated control costs associated with wind erosion prevention requirements to be \$100 per acre or \$154 per ton PM10 reduced (1993 dollars). This estimate was derived from cost estimates developed for stabilization of fallow fields, which along with the cessation of tilling on high-wind days, is considered to be the most likely control included in the soil conservation plans (SCAQMD, 1996). No capital expenditures have been identified, as most of the potential control actions include a change in agricultural methods using equipment already possessed by farm owners/operators.

Conversion to 1990 dollars was done using the U.S. Department of Agriculture's index for prices paid for farm services/operations (Pechan, 1997).

Cost Effectiveness: The cost effectiveness is \$138 per ton PM10 reduced (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 1997

AT-A-GLANCE TABLE FOR AREA SOURCES

Additional Information:

Agricultural tilling is used for soil preparation and maintenance, and generally produces the bulk of fugitive dust emissions from agricultural activities. Tilling includes plowing, harrowing, land leveling, disking, and cultivating.

References:

Pechan, 1997: E.H. Pechan & Associates, "Additional Control Measure Evaluation for the Integrated Implementation of the Ozone and Particulate Matter National Ambient Air Quality Standards, and Regional Haze Program," prepared for U.S. Environmental Protection Agency, July 1997.

SCAQMD, 1996: South Coast Air Quality Management District, "1997 Air Quality Management Plan, Appendix IV-A: Stationary and Mobile Source Control Measures." August 1996.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Asphalt Manufacture

Control Measure Name: Fabric Filter (Pulse Jet Type)

Rule Name: Not Applicable

Pechan Measure Code: P2221

POD: 222

Application: This control is the addition of a pulse-jet cleaned fabric filter to reduce PM emissions from waste streams. In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Particulate-laden gas flows into the filter bag from the outside to the inside. The particles collected on the outside drop into a hopper below the fabric filter. During pulse-jet cleaning, a short burst of high pressure air is injected into the bags, dislodging the dust cake.

This control applies to asphalt manufacturing operations.

Affected SCC:

30500101 Asphalt Roofing Manufacture, Asphalt Blowing: Saturant (Use 3-05-050-10 for MACT)
30500102 Mineral Products, Asphalt Roofing, Asphalt Blowing-Coating (Use 30505010 for MACT)
30500103 Asphalt Roofing Manufacture, Felt Saturation: Dipping Only
30500105 Asphalt Roofing Manufacture, General **
30500106 Asphalt Roofing Manufacture, Shingles and Rolls: Spraying Only
30500108 Asphalt Roofing Manufacture, Shingles and Rolls: Coating
30500110 Asphalt Roofing Manufacture, Blowing (Use 3-05-050-01 for MACT)
30500111 Mineral Products, Asphalt Roofing Manufacture, Dipping Only
30500117 Asphalt Roofing, Shingle Saturation-Dip Saturator, Drying-in Drum & Coater
30500198 Mineral Products, Asphalt Roofing Manufacture, Other Not Classified
30500201 Mineral Prod, Asphalt/Concrete, Rotary Dryer-Conventional (See 305002-50 -51 -52)
30500202 Mineral Products, Asphalt Concrete, Hot Elevators, Screens, Bins and Mixer
30500203 Mineral Products, Asphalt Concrete, Storage Piles
30500204 Mineral Products, Asphalt Concrete, Cold Aggregate Handling
30500205 Mineral Prod, Asphalt Concrete, Drum Dryer-Hot Asphalt Plants (See 305002-55, -58)
30500208 Mineral Products, Asphalt Concrete, Asphalt Heater-Distillate Oil (30505022 for MACT)
30500211 Asphalt Concrete, Rotary Dryer Conventional Plant-Cyclone (30500201 w/CTL)
30500213 Asphalt Concrete, Storage Silo
30500221 Asphalt Concrete, Elevators: Continuous Process
30500242 Asphalt Concrete, Mixers: Drum Mix Process ** (use 3-05-002-005 and subtypes)
30500290 Asphalt Concrete, Haul Roads: General
30500299 Asphalt Concrete, See Comment **

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 99% from uncontrolled for both PM10 and PM2.5

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs for pulse-jet cleaned systems are generated using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). When stack gas flow rate data was

AT-A-GLANCE TABLE FOR POINT SOURCES

available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan,2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 2000). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$6 to \$26 per scfm

Typical value is \$13 per scfm

O&M Costs:

Range from \$5 to \$24 per scfm

Typical value is \$11 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). O&M costs were calculated for three model plants with flow rates of 25, 75 and 150 thousand acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust loading of 4.0 grains per cubic feet. The operating time was assumed to be 8760 hours per year. An average bag cost was estimated using the costs for standard bag types. Capital recovery for the periodic replacement of bags was included in the O&M cost of the bags using a bag life of 2 years (EPA, 1998a). The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.0671	\$/kW-hr
Compressed air	0.25	\$/1000 scf
Dust disposal	25	\$/ton disposed

Note: All costs are in 1998 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$42 to \$266 per ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$117 per ton PM10 reduced.

AT-A-GLANCE TABLE FOR POINT SOURCES

(1998\$)

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

The cost estimates assume a conventional design under typical operating conditions and do not include auxiliary equipment such as fans and ductwork. The costs for pulse-jet cleaned systems are generated using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a).

Costs are primarily based on volumetric flow rate and the amount of PM in the waste stream. In general, a small unit controlling a low pollutant levels will not be as cost effective as a large unit controlling a high pollutant levels. (EPA, 2000)

Pollutants requiring a high level of control or the fabric filters to be constructed of special materials will increase the costs of the system (EPA, 1998a). The additional costs for controlling complex waste streams are not included in the estimates. For these systems, the capital cost could increase by as much as 75% and the operational and maintenance (O&M) cost could increase by as much as 20% (EPA, 2000).

In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Fabric filters may be in the form of sheets, cartridges, or bags, with many individual filter units together in a group. Bags are the most common type of filter. The dust cake that forms on the filter from the collected PM can significantly increase collection efficiency. (EPA, 2000)

Pulse-jet cleaning of fabric filters is a relatively new type of fabric filter, as they have only been used for the past 30 years. This cleaning mechanism has grown in popularity because it can treat high dust loadings, operate at constant pressure drop, and occupy less space than other types of fabric filters (EPA, 2000). Particulate-laden gas flows into the bag. The gas flows from the outside to the inside of the bags, and then out the gas exhaust. The particles collected on the outside drop into a hopper below the fabric filter (EPA, 1998b).

During pulse-jet cleaning, a short burst of high pressure air is injected into the bags (EPA, 1998b). The pulse is blown through a venturi nozzle at the top of the bags and establishes a shock wave that continues onto the bottom of the bag. The wave flexes the fabric dislodging the dust cake.

There are several unique attributes of pulse-jet cleaning. The cleaning pulse is very brief allowing the flow of dusty gas to continue during cleaning. The bags not being cleaned continue to filter, taking on extra duty from the bags being cleaned (EPA, 2000). Pulse-jet cleaning is more intense and occurs with greater frequency than the other fabric filter cleaning methods. The cleaning dislodges nearly all of the dust cake each time the bag is pulsed. Pulse-jet filters, as a result, do not rely on a dust cake to provide filtration. Felted (non-woven) fabrics are used in these types of filters because they do not require a dust cake. Also it has been found that woven fabrics used with pulse-jet cleaning leak dust after they are cleaned (EPA, 1998b).

Since bags cleaned by the pulse-jet method do not need to be isolated for cleaning, pulsejet cleaned fabric filters do not need extra compartments to maintain adequate filtration during cleaning. Also, because of the intense and frequent nature of the cleaning, they can treat higher gas flow rates with higher dust loadings. Consequently, fabric filters cleaned by the pulse-jet method can be smaller than other filters in the treatment of the same amount of gas and dust, making higher gas-to-cloth ratios achievable (EPA, 1998b).

AT-A-GLANCE TABLE FOR POINT SOURCES

Fabric filters are useful for collecting particles with resistivities either too low or too high for collection with electrostatic precipitators. Fabric filters are useful in controlling particulate matter less than or equal to 10 micrometers (μm) in diameter (PM10) and particulate matter less than or equal to 2.5 μm in diameter (PM2.5). Fabric filters may be good candidates for collecting fly ash from low-sulfur coals or containing high unburned carbon levels and are relatively difficult to collect with electrostatic precipitators. (EPA, 2000)

References:

EPA, 1998a: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, Chapter 5, EPA 453/B-96-001, Research Triangle Park, NC. December 1998.

EPA, 1998b: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

EPA, 2000: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Fabric Filter - Pulse-Jet Cleaned Type," April 2000.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Asphalt Manufacture

Control Measure Name: Fabric Filter (Mech. Shaker Type)

Rule Name: Not Applicable

Pechan Measure Code: P2222

POD: 222

Application: This control is the addition of a mechanical shaker type fabric filter to reduce PM emissions. In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. The gas stream is drawn from beneath a cell plate in the floor and into the filter bags. The gas proceeds from the inside to the outside of the filter bags. The particles collect on the inside of the bags, forming a filter cake. In mechanical shaking units, the tops of bags are attached to a shaker bar, moved briskly to clean the bags.

This control applies to asphalt manufacturing processes.

Affected SCC:

30500101 Asphalt Roofing Manufacture, Asphalt Blowing: Saturant (Use 3-05-050-10 for MACT)
30500102 Mineral Products, Asphalt Roofing, Asphalt Blowing-Coating (Use 30505010 for MACT)
30500103 Asphalt Roofing Manufacture, Felt Saturation: Dipping Only
30500105 Asphalt Roofing Manufacture, General **
30500106 Asphalt Roofing Manufacture, Shingles and Rolls: Spraying Only
30500108 Asphalt Roofing Manufacture, Shingles and Rolls: Coating
30500110 Asphalt Roofing Manufacture, Blowing (Use 3-05-050-01 for MACT)
30500111 Mineral Products, Asphalt Roofing Manufacture, Dipping Only
30500117 Asphalt Roofing, Shingle Saturation-Dip Saturator, Drying-in Drum & Coater
30500198 Mineral Products, Asphalt Roofing Manufacture, Other Not Classified
30500201 Mineral Prod, Asphalt/Concrete, Rotary Dryer-Conventional (See 305002-50 -51 -52)
30500202 Mineral Products, Asphalt Concrete, Hot Elevators, Screens, Bins and Mixer
30500203 Mineral Products, Asphalt Concrete, Storage Piles
30500204 Mineral Products, Asphalt Concrete, Cold Aggregate Handling
30500205 Mineral Prod, Asphalt Concrete, Drum Dryer-Hot Asphalt Plants (See 305002-55, -58)
30500208 Mineral Products, Asphalt Concrete, Asphalt Heater-Distillate Oil (30505022 for MACT)
30500211 Asphalt Concrete, Rotary Dryer Conventional Plant-Cyclone (30500201 w/CTL)
30500213 Asphalt Concrete, Storage Silo
30500221 Asphalt Concrete, Elevators: Continuous Process
30500242 Asphalt Concrete, Mixers: Drum Mix Process ** (use 3-05-002-005 and subtypes)
30500290 Asphalt Concrete, Haul Roads: General
30500299 Asphalt Concrete, See Comment **

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 99% from uncontrolled for both PM10 and PM2.5

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

AT-A-GLANCE TABLE FOR POINT SOURCES

Cost Basis: The costs for mechanical shaker cleaned systems are generated using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan, 2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 2000). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$8 to \$71 per scfm

Typical value is \$29 per scfm

O&M Costs:

Range from \$4 to \$24 per scfm

Typical value is \$11 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). O&M costs were calculated for three model plants with flow rates of 25, 75 and 150 thousand acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust loading of 4.0 grains per cubic feet. The operating time was assumed to be 8760 hours per year. An average bag cost was estimated using the costs for standard bag types. Capital recovery for the periodic replacement of bags was included in the O&M cost of the bags using a bag life of 2 years (EPA, 1998a). The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.0671	\$/kW-hr
Compressed air	0.25	\$/1000 scf
Dust disposal	25	\$/ton disposed

Note: All costs are in 1998 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$37 to \$303 per

AT-A-GLANCE TABLE FOR POINT SOURCES

ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$126 per ton PM10 reduced. (1998\$)

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

Cost estimates assume a conventional design under typical operating conditions. The costs do not include auxiliary equipment such as fans and ductwork. (EPA, 2000)

Costs are primarily based on volumetric flow rate and the amount of PM in the waste stream. In general, a small unit controlling a low pollutant levels will not be as cost effective as a large unit controlling a high pollutant levels. (EPA, 2000)

Pollutants requiring a high level of control or the fabric filters to be constructed of special materials will increase the costs of the system (EPA, 1998a). The additional costs for controlling complex waste streams are not included in the estimates. For these systems, the capital cost could increase by as much as 30% and the O&M cost could increase by as much as 7%.

In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Fabric filters may be in the form of sheets, cartridges, or bags, with many individual filter units together in a group. Bags are the most common type of filter. The dust cake that forms on the filter from the collected PM can significantly increase collection efficiency. (EPA, 2000)

Mechanical shaking is a popular cleaning method because it is both simple and effective. In typical operation, dusty gas enters an inlet pipe to the fabric filter and very large particles are removed using a baffle plate fall into the hopper. The gas stream is drawn from beneath a cell plate in the floor and into the filter bags (EPA, 2000). The gas proceeds from the inside to the outside of the filter bags. The particles collect on the inside of the bags, forming a filter cake. In mechanical shaking units, the tops of bags are attached to a shaker bar, moved briskly (usually in a horizontal direction) to clean the bags. The shaker bars are operated by mechanical motors or by hand (EPA, 1998b)..

Fabric filters are useful for collecting particles with resistivities either too low or too high for collection with electrostatic precipitators. Fabric filters are useful in controlling particulate matter less than or equal to 10 micrometers (μm) in diameter (PM10) and particulate matter less than or equal to 2.5 μm in diameter (PM2.5). Fabric filters may be good candidates for collecting fly ash from low-sulfur coals or containing high unburned carbon levels and are relatively difficult to collect with electrostatic precipitators. (EPA, 2000)

References:

EPA, 1998a: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, Chapter 5, EPA 453/B-96-001, Research Triangle Park, NC. December 1998.

EPA, 1998b: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

EPA, 2000: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution

AT-A-GLANCE TABLE FOR POINT SOURCES

Technology Fact Sheet - Fabric Filter - Mechanical Shaker Cleaned Type," August 2000.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Asphalt Manufacture

Control Measure Name: Paper/Nonwoven Filters - Cartridge Collector Type

Rule Name: Not Applicable

Pechan Measure Code: P2223

POD: 222

Application: This control is the use of paper or non-woven filters (cartridge collector type) to reduce PM emissions. The waste gas stream is passed through the fibrous filter media causing PM in the gas stream to be collected on the media by sieving and other mechanisms.

This control measure applies to asphalt manufacturing operations.

Affected SCC:

30500101 Asphalt Roofing Manufacture, Asphalt Blowing: Saturant (Use 3-05-050-10 for MACT)
30500102 Mineral Products, Asphalt Roofing, Asphalt Blowing-Coating (Use 30505010 for MACT)
30500103 Asphalt Roofing Manufacture, Felt Saturation: Dipping Only
30500105 Asphalt Roofing Manufacture, General **
30500106 Asphalt Roofing Manufacture, Shingles and Rolls: Spraying Only
30500108 Asphalt Roofing Manufacture, Shingles and Rolls: Coating
30500110 Asphalt Roofing Manufacture, Blowing (Use 3-05-050-01 for MACT)
30500111 Mineral Products, Asphalt Roofing Manufacture, Dipping Only
30500117 Asphalt Roofing, Shingle Saturation-Dip Saturator, Drying-in Drum & Coater
30500198 Mineral Products, Asphalt Roofing Manufacture, Other Not Classified
30500201 Mineral Prod, Asphalt/Concrete, Rotary Dryer-Conventional (See 305002-50 -51 -52)
30500202 Mineral Products, Asphalt Concrete, Hot Elevators, Screens, Bins and Mixer
30500203 Mineral Products, Asphalt Concrete, Storage Piles
30500204 Mineral Products, Asphalt Concrete, Cold Aggregate Handling
30500205 Mineral Prod, Asphalt Concrete, Drum Dryer-Hot Asphalt Plants (See 305002-55, -58)
30500208 Mineral Products, Asphalt Concrete, Asphalt Heater-Distillate Oil (30505022 for MACT)
30500211 Asphalt Concrete, Rotary Dryer Conventional Plant-Cyclone (30500201 w/CTL)
30500213 Asphalt Concrete, Storage Silo
30500221 Asphalt Concrete, Elevators: Continuous Process
30500242 Asphalt Concrete, Mixers: Drum Mix Process ** (use 3-05-002-005 and subtypes)
30500290 Asphalt Concrete, Haul Roads: General
30500299 Asphalt Concrete, See Comment **

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 99% from uncontrolled for both PM10 and PM2.5

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs are generated using EPA's cost-estimating spreadsheets for fabric filters (EPA, 1998a). Costs are primarily driven by the waste stream volumetric flow rate and pollutant loading. When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs.

AT-A-GLANCE TABLE FOR POINT SOURCES

When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan,2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 2000). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$7 to \$13 per scfm
Typical value is \$9 per scfm

O&M Costs:

Range from \$9 to \$25 per scfm
Typical value is \$14 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). O&M costs were calculated for three model plants with flow rates of 25, 75 and 150 thousand acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust loading of 4.0 grains per cubic feet. The operating time was assumed to be 8760 hours per year. An average cartridge cost was estimated using the costs for standard cartridge types. Capital recovery for the periodic replacement of cartridges was included in the O&M cost of the cartridges using a cartridge life of 2 years (EPA, 1998a). The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.0671	\$/kW-hr
Compressed air	0.25	\$/1000 scf
Dust disposal	25	\$/ton disposed

Note: All costs are in 1998 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$85 to \$256 per ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$142 per ton PM10 reduced. (1998\$)

Comments:

AT-A-GLANCE TABLE FOR POINT SOURCES

Status: Demonstrated	Last Reviewed: 2001
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Additional Information:

Materials handling operations including crushing, grinding, and screening, can produce significant PM emissions. Drying, the heating of minerals or mineral products to remove water, and calcination, heating to higher temperatures to remove chemically bound water and other compounds, are normally performed in dedicated, closed units. Emissions from these units will be through process vents, to which PM controls can be applied relatively simply. Fugitive dust emissions may come from paved and unpaved roads in plants and from raw material and product loading, unloading, and storage (STAPPA/ALAPCO, 1996).

The cost estimates assume a conventional design under typical operating conditions. Auxiliary equipment, such as fans and ductwork, is not included (EPA, 2000). Pollutants that require an unusually high level of control or that require the filter media or the unit itself to be constructed of special materials, such as Nomex ® or stainless steel, will increase the costs of the system (EPA, 1998a). The additional costs for controlling more complex waste streams are not reflected in the estimates given below. For these types of systems, the capital cost could increase by as much as 75% and the O&M cost could increase by as much as 10%. In general, a small unit controlling a low pollutant loading will not be as cost effective as a large unit controlling a high pollutant loading (EPA, 2000).

Cartridge filters contain either a paper or nonwoven fibrous filter media (EPA, 2000). Paper media is generally made of materials such as cellulose and fiberglass. The dust cake that forms on the filter media from the collected PM can significantly increase collection efficiency (EPA, 1998b).

In general, the filter media is pleated to provide a larger surface area to volume flow rate. Close pleating, however, can cause PM to bridge the pleat bottom, effectively reducing the surface collection area (EPA, 1998b). Corrugated aluminum separators are used to prevent the pleats from collapsing (Heumann, 1997). There are variety of cartridge designs and dimensions. Typical designs include flat panels, V-shaped packs or cylindrical packs (Heumann, 1997). For certain applications, two cartridges may be placed in series.

Cartridge collectors are useful for collecting particles with resistivities either too low or too high for collection with electrostatic precipitators (STAPPA/ALAPCO, 1996). For similar air flow rates, cartridge collectors are compact in size compared to traditional bag.

References:

EPA, 1998b: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, Chapter 5, EPA 453/B-96-001, Research Triangle Park, NC. December 1998.

EPA, 1998a: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

EPA, 2000: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Cartridge Collector with Pulse-Jet Cleaning," April 2000.

Heumann, 1997: W. L. Heumann, "Industrial Air Pollution Control Systems," McGraw Hill Publishers, Inc., Washington, D.C., 1997.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter

AT-A-GLANCE TABLE FOR POINT SOURCES

Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

STAPPA/ALAPCO, 1996: State and Territorial Air Pollution Program Administrators and Association of Local Air Pollution Control Officials, "Controlling Particulate Matter Under the Clean Air Act: A Menu of Options," July 1996.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Asphalt Manufacture

Control Measure Name: Fabric Filter (Reverse-Air Cleaned Type)

Rule Name: Not Applicable

Pechan Measure Code: P2224

POD: 222

Application: This control is the use of a reverse-air cleaned fabric filter to reduce PM emissions from waste streams. In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Reverse-air cleaning is performed by forcing clean air through the filters in the opposite direction of the dusty gas flow. The change in direction of the gas flow causes the bag to flex and crack the filter cake allowing for internal cake collection.

This control applies to asphalt manufacturing operations

Affected SCC:

30500101 Asphalt Roofing Manufacture, Asphalt Blowing: Saturant (Use 3-05-050-10 for MACT)
30500102 Mineral Products, Asphalt Roofing, Asphalt Blowing-Coating (Use 30505010 for MACT)
30500103 Asphalt Roofing Manufacture, Felt Saturation: Dipping Only
30500105 Asphalt Roofing Manufacture, General **
30500106 Asphalt Roofing Manufacture, Shingles and Rolls: Spraying Only
30500108 Asphalt Roofing Manufacture, Shingles and Rolls: Coating
30500110 Asphalt Roofing Manufacture, Blowing (Use 3-05-050-01 for MACT)
30500111 Mineral Products, Asphalt Roofing Manufacture, Dipping Only
30500117 Asphalt Roofing, Shingle Saturation-Dip Saturator, Drying-in Drum & Coater
30500198 Mineral Products, Asphalt Roofing Manufacture, Other Not Classified
30500201 Mineral Prod, Asphalt/Concrete, Rotary Dryer-Conventional (See 305002-50 -51 -52)
30500202 Mineral Products, Asphalt Concrete, Hot Elevators, Screens, Bins and Mixer
30500203 Mineral Products, Asphalt Concrete, Storage Piles
30500204 Mineral Products, Asphalt Concrete, Cold Aggregate Handling
30500205 Mineral Prod, Asphalt Concrete, Drum Dryer-Hot Asphalt Plants (See 305002-55, -58)
30500208 Mineral Products, Asphalt Concrete, Asphalt Heater-Distillate Oil (30505022 for MACT)
30500211 Asphalt Concrete, Rotary Dryer Conventional Plant-Cyclone (30500201 w/CTL)
30500213 Asphalt Concrete, Storage Silo
30500221 Asphalt Concrete, Elevators: Continuous Process
30500242 Asphalt Concrete, Mixers: Drum Mix Process ** (use 3-05-002-005 and subtypes)
30500290 Asphalt Concrete, Haul Roads: General
30500299 Asphalt Concrete, See Comment **

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 99% from uncontrolled for both PM10 and PM2.5

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs for reverse-air cleaned systems are generated using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). When stack gas flow rate data was

AT-A-GLANCE TABLE FOR POINT SOURCES

available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM₁₀ removed were used (Pechan, 2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 2000). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$9 to \$84 per scfm

Typical value is \$34 per scfm

O&M Costs:

Range from \$6 to \$27 per scfm

Typical value is \$13 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). O&M costs were calculated for three model plants with flow rates of 25, 75 and 150 thousand acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust loading of 4.0 grains per cubic feet. The operating time was assumed to be 8760 hours per year. An average bag cost was estimated using the costs for standard bag types. Capital recovery for the periodic replacement of bags was included in the O&M cost of the bags using a bag life of 2 years (EPA, 1998a). The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.0671	\$/kW-hr
Compressed air	0.25	\$/1000 scf
Dust disposal	25	\$/ton disposed

Note: All costs are in 1998 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$53 to \$337 per ton PM₁₀ removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$148 per ton PM₁₀ reduced.

AT-A-GLANCE TABLE FOR POINT SOURCES

(1998\$)

Comments:

Status: Demonstrated**Last Reviewed:** 2001

Additional Information:

Hot mix asphalt (HMA) paving material is a scientifically proportioned mixture of graded aggregates and asphalt cement. The process of producing involves drying and heating the aggregates to prepare them for the asphalt cement coating.

The cost estimates assume a conventional design under typical operating conditions. The costs do not include any auxiliary equipment (EPA, 2000).

The capital cost for the reverse-jet cleaned fabric baghouse is based on information provided by a manufacturer (EPA, 2000). The capital cost includes only the purchased equipment cost.

Costs are primarily based on volumetric flow rate and the amount of PM in the waste stream. In general, a small unit controlling a low pollutant levels will not be as cost effective as a large unit controlling a high pollutant levels. (EPA, 2000)

Pollutants requiring a high level of control or the fabric filters to be constructed of special materials will increase the costs of the system (EPA, 1998a). The additional costs for controlling complex streams are not reflected in the estimates. For these systems, the capital cost could increase by as much as 40% and the O&M cost could increase by as much as 5%. (EPA, 2000)

In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Fabric filters may be in the form of sheets, cartridges, or bags, with many individual filter units together in a group. Bags are the most common type of filter. The dust cake that forms on the filter from the collected PM can significantly increase collection efficiency. (EPA, 2000)

Reverse-air cleaning is a popular filter cleaning method as it has been used extensively and improved over the years. It is a gentler but sometimes less effective clearing mechanism than mechanical shaking. Reverse-air cleaning is performed by forcing clean air through the filters in the opposite direction of the dusty gas flow. The change in direction of the gas flow causes the bag to flex and crack the filter cake allowing for internal cake collection (EPA, 2000).

The most common design is to have separate compartments within the fabric filter so that each can be isolated and cleaned separately while the others continue to treat the dusty gas. There are several methods of reversing the flow through the filters. One method of providing the reverse flow is by the use of a fan or cleaned gas from other compartments. Reverse-air cleaning only used alone in cases where the dust releases easily from the fabric. In many instances, reverse-air is used along with shaking, pulsing or sonic horns (EPA, 1998b).

Fabric filters are useful for collecting particles with resistivities either too low or too high for collection with electrostatic precipitators. Fabric filters are useful in controlling particulate matter less than or equal to 10 micrometers (μm) in diameter (PM₁₀) and particulate matter less than or equal to 2.5 μm in diameter (PM_{2.5}). Fabric filters may be good candidates for collecting fly ash from low-sulfur coals or containing high unburned carbon levels and are relatively difficult to collect with electrostatic precipitators. (EPA, 2000)

AT-A-GLANCE TABLE FOR POINT SOURCES

References:

EPA, 1998b: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter, EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

EPA, 1998a: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, Chapter 5, EPA 453/B-96-001, Research Triangle Park, NC. December 1998.

EPA, 2000: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Fabric Filter - Reverse-Air Cleaned Type," April 2000.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Asphalt Manufacture

Control Measure Name: Increased Monitoring Frequency (IMF) of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P3222

POD: 222

Application: This measure is to conduct improved monitoring for PM_{2.5} emissions at stationary sources. Improved monitoring in this case means increasing the monitoring frequency of electrostatic precipitators, scrubbers, and fabric filters from once per day to four times per hour, with no change in monitoring technique.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (Barr and Schaffner) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

305001** Mineral Products, Asphalt Roofing Manufacture

305002** Mineral Products, Asphalt Concrete

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 6.5% for both PM₁₀ and PM_{2.5}

Equipment Life: Not applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs included the incremental record keeping and reporting associated with the increased monitoring frequency. Labor rates for 2003 were made that were obtained from the Bureau of Labor Statistics (labor rates include 140 percent overhead). The incremental costs included a one-time cost for development of the improved monitoring and recurring annual burden costs for incremental record keeping, reporting, and certification activities.

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$620 per ton PM reduced (2003\$).

Comments:

Status:

Last Reviewed: 2004

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM2.5 Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 2003.

BLS, 2003: Bureau of Labor Statistics, "Employer Costs for Employee Compensation – June 2003," Table 12, page 16, 2003.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Asphalt Manufacture

Control Measure Name: CEM Upgrade and Increased Monitoring Frequency of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P4222

POD: 222

Application: This measure examines the impacts of improving the PM monitoring technique at units currently using an ESP, scrubber, or fabric filter. In this improved technique scenario, the monitoring technique is upgraded to a PM continuous emission monitor. This improved monitoring technique also results in an increase to the monitoring frequency because a PM CEMS can make a measurement every 7.5 minutes. The monitoring frequency increases from once per day to eight times per hour.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (see References) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

305001** Mineral Products, Asphalt Roofing Manufacture

305002** Mineral Products, Asphalt Concrete

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 7.7% for both PM10 and PM2.5

Equipment Life: Unknown

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The total capital and annual operating costs for implementing an improved monitoring technique are calculated based on data from the EPA CEMS Cost Model and the PM CEMS Knowledge document. Labor rates in the EPA CEMS Cost Model are scaled to reflect 2003 labor rates (including 140 percent overhead) provided by the Bureau of Labor Statistics.

The cost effectiveness at a percent excess emission rate of 0.46 percent is \$5,200 per ton of PM2.5. This is based on a \$34 million capital investment cost, and a \$14 million total annualized cost when applied to 128 facilities.

Note: All costs are in 2003 dollars.

AT-A-GLANCE TABLE FOR POINT SOURCES

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$5,200 per ton PM reduced (2003\$).

Comments:

Status:

Last Reviewed: 2004

Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM_{2.5} Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 8, 2003.

EPA CEMS Cost Model, Version 3.0, U.S. Environmental Protection Agency.

EPA, 2000: U.S. Environmental Protection Agency, "Current Knowledge of Particulate Matter (PM) Continuous Emissions Monitoring," Chapter 9, PM CEMS Cost, September 8, 2000.

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Beef Cattle Feedlots

Control Measure Name: Watering

Rule Name: Not Applicable

Pechan Measure Code: Pcatf

POD: N/A

Application: Control of fugitive dust emissions from agricultural (cattle) feedlots is most often performed by watering from either stationary sprinklers or from water trucks.

This control is applicable to all beef cattle feedlots classified under SCC 2805001000.

Affected SCC:

2805001000 Beef Cattle Feedlots, Total (also see 2805020000)

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: PM10 control efficiency is 50% from uncontrolled; PM2.5 control efficiency is 25% from uncontrolled

Equipment Life: 10 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Control costs were estimated by assuming that installation of a stationary sprinkler system is required. Peters profiled estimates of capital and O&M costs (Peters, 1977). The mid-range capital cost was \$6.50 per head and the mid-range O&M cost was \$0.30 per head. Both of these figures are in 1975 dollars. Assuming a 10-year life and 5% discount rate for the sprinkler system, the TACs are \$1.58 per head (1975\$). To estimate cost per ton of PM10 reduced the emission factor (0.017 tons/head) and the control efficiency (50%) are applied to yield \$186 per ton PM10 reduced (1975\$).

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$307 per ton PM reduced (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 1998

Additional Information:

References:

Pechan, 1998: E.H. Pechan & Associates, Inc., "Clean Air Act Section 812 Prospective Cost Analysis - Draft Report," prepared for Industrial Economics, Inc., Cambridge, MA, September 1998.

Peters, 1977: J.A. Peters, and T>R> Blackwood, Monsanto Research Corporation, "Source Assessment: Beef Cattle Feedlots," prepared for U.S. Environmental Agency, Office of Research and Development, Research Triangle Park, NC, June 1977.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Chemical Manufacture

Control Measure Name: Wet ESP - Wire Plate Type

Rule Name: Not Applicable

Pechan Measure Code: P2251

POD: 225

Application: This control is the use of a wire-plate type electrostatic precipitator (ESP) to reduce PM emissions. An ESP uses electrical forces to move particles in an exhaust stream onto collector plates. Electrodes in the center of the flow are maintained at high voltage and generate an electrical field forcing particles to the collector walls. Wet ESPs use a stream of water, in place of rapping mechanisms, to dislodge particulate from the plates and into a sump.

This control applies to various chemical manufacturing operations, including (but not limited to) adipic acid, ammonia, carbon black, charcoal, cleaners, phosphoric acids, plastics, sulfuric acid, sodium carbonate, ammonium nitrate, rubbers, ammonium phosphates, and inorganic pigments.

Affected SCC:

30100104 Adipic Acid, Nitric Acid Reaction
30100106 Adipic Acid, Drying, Loading, and Storage
30100199 Adipic Acid, Other Not Classified
30100305 Ammonia Production, Feedstock Desulfurization
30100306 Ammonia Production, Primary Reformer: Natural Gas Fired
30100309 Ammonia Production, Condensate Stripper
30100310 Ammonia Production, Storage and Loading Tanks
30100399 Ammonia Production, Other Not Classified
30100502 Carbon Black Production, Thermal Process
30100503 Carbon Black Production, Gas Furnace Process: Main Process Vent
30100504 Carbon Black Production, Oil Furnace Process: Main Process Vent
30100506 Carbon Black Production, Transport Air Vent
30100507 Carbon Black Production, Pellet Dryer
30100508 Carbon Black Production, Bagging/Loading
30100509 Carbon Black Production, Furnace Process: Fugitive Emissions
30100599 Carbon Black Production, Other Not Classified
30100601 Chemical Manufacturing, Charcoal Manufacturing, General
30100603 Charcoal Manufacturing, Batch Kiln
30100604 Charcoal Manufacturing, Continuous Kiln
30100605 Charcoal Manufacturing, Briquetting
30100699 Chemical Manufacturing, Charcoal Manufacturing, Other Not Classified
30100799 Chlorine, Other Not Classified **
30100801 Chloro-alkali Production, Liquefaction (Diaphragm Cell Process)
30100802 Chloro-alkali Production, Liquefaction (Mercury Cell Process)
30100899 Chloro-alkali Production, Other Not Classified
30100901 Chemical Manufacturing, Cleaning Chemicals, Spray Drying: Soaps and Detergents
30100902 Chemical Manufacturing, Cleaning Chemicals, Specialty Cleaners
30100999 Chemical Manufacturing, Cleaning Chemicals, Other Not Classified
30101001 Chemical Manufacturing, Explosives (Trinitrotoluene)
30101199 Hydrochloric Acid, Other Not Classified
30101205 Hydrofluoric Acid, Fluorspar Transfer
30101401 Chemical Manufacturing, Paint Manufacture, General Mixing and Handling

AT-A-GLANCE TABLE FOR POINT SOURCES

30101402 Chemical Manufacturing, Paint Manufacture, Pigment Handling
30101415 Paint Manufacture, Premix/Preassembly
30101499 Paint Manufacture, Other Not Classified
30101599 Chemical Manufacturing, Varnish Manufacturing, Other Not Classified
30101601 Phosphoric Acid: Wet Process, Reactor
30101602 Phosphoric Acid: Wet Process, Gypsum Pond
30101699 Phosphoric Acid: Wet Process, Other Not Classified
30101702 Phosphoric Acid: Thermal Process, Absorber: General
30101703 Phosphoric Acid: Thermal Process, Absorber with Packed Tower
30101704 Phosphoric Acid: Thermal Process, Absorber with Venturi Scrubber
30101706 Phosphoric Acid: Thermal Process, Absorber with Wire Mist Eliminator
30101799 Phosphoric Acid: Thermal Process, Other Not Classified
30101801 Plastics Production, Polyvinyl Chlorides and Copolymers ** (Use 6-46-3X0-XX)
30101802 Plastics Production, Polypropylene and Copolymers
30101805 Chemical Manufacturing, Plastics Production, Phenolic Resins
30101807 Plastics Production, General: Polyethylene (High Density)
30101810 Plastics Production, Conveying
30101812 Plastics Production, General: Polyethylene (Low Density)
30101819 Plastics Production, Solvent Recovery
30101821 Plastics Production, Extruding/Pelletizing/Conveying/Storage
30101822 Plastics Production, Acrylic Resins
30101827 Plastics Production, Polyamide Resins
30101837 Plastics Production, Polyester Resins
30101838 Plastics Production, Reactor Kettle ** (Use 6-45-200-11 or 6-45-210-11)
30101849 Plastics Production, Acrylonitrile-Butadiene-Styrene (ABS) Resin
30101883 Plastics Production, Transferring/Conveying/Storage (Polyurethane)
30101892 Plastics Production, Separation Processes
30101899 Chemical Manufacturing, Plastics Production, Others Not Specified
30101901 Phthalic Anhydride, o-Xylene Oxidation: Main Process Stream
30102001 Chemical Manufacturing, Printing Ink Manufacture, Vehicle Cooking: General
30102005 Chemical Manufacturing, Printing Ink Manufacture, Pigment Mixing
30102099 Printing Ink Manufacture, Other Not Classified
30102102 Sodium Carbonate, Solvay Process: Handling
30102113 Sodium Carbonate, Bleacher: Gas-fired
30102121 Sodium Carbonate, Ore Crushing and Screening
30102122 Sodium Carbonate, Soda Ash Storage: Loading and Unloading
30102127 Sodium Carbonate, Soda Ash Screening
30102199 Sodium Carbonate, Other Not Classified
30102301 Chemical Manufacturing, Sulfuric Acid (Contact Process), Absorber/@ 99.9% Conversion
30102304 Sulfuric Acid (Contact Process), Absorber/@ 99.5% Conversion
30102306 Sulfuric Acid (Contact Process), Absorber/@ 99.0% Conversion
30102308 Sulfuric Acid (Contact Process), Absorber/@ 98.0% Conversion
30102318 Sulfuric Acid (Contact Process), Absorber/@ 93.0% Conversion
30102399 Chemical Manufacturing, Sulfuric Acid (Contact Process), Other Not Classified
30102401 Synthetic Organic Fiber Manufacturing, Nylon #6: Staple (Uncontrolled)
30102402 Synthetic Organic Fiber Manufacturing, Polyesters: Staple
30102414 Synthetic Organic Fiber Manufacturing, Polyolefin: Melt Spun
30102499 Synthetic Organic Fiber Manufacturing, Other Not Classified
30102501 Cellulosic Fiber Production, Viscose (e.g., Rayon) ** (Use 6-49-200-XX)
30102505 Cellulosic Fiber Production, Cellulose Acetate: Filer Tow
30102601 Synthetic Rubber (Manufacturing Only), General
30102614 Synthetic Rubber (Manufacturing Only), Blending Tanks

AT-A-GLANCE TABLE FOR POINT SOURCES

30102656 Synthetic Rubber (Manufacturing Only), Fugitive Emissions: Carbon Black Storage
30102699 Synthetic Rubber (Manufacturing Only), Other Not Classified
30102701 Ammonium Nitrate Production, Prilling Tower: Neutralizer **
30102704 Ammonium Nitrate Production, Neutralizer
30102707 Ammonium Nitrate Production, Rotary Drum Granulator
30102709 Ammonium Nitrate Production, Bulk Loading (General)
30102710 Ammonium Nitrate Production, Bagging of Product
30102711 Ammonium Nitrate Production, Neutralizer: High Density
30102712 Ammonium Nitrate Production, Prilling Tower: High Density
30102713 Ammonium Nitrate Production, High Density Dryers and Coolers (scb**
30102714 Ammonium Nitrate Production, Prilling Cooler: High Density
30102717 Ammonium Nitrate Production, Evaporator/Concentrator: High Density
30102718 Ammonium Nitrate Production, Coating: High Density
30102721 Ammonium Nitrate Production, Neutralizer: Low Density
30102722 Ammonium Nitrate Production, Prilling Tower: Low Density
30102724 Ammonium Nitrate Production, Prilling Cooler: Low Density
30102725 Ammonium Nitrate Production, Prilling Dryer: Low Density
30102727 Ammonium Nitrate Production, Evaporator/Concentrator: Low Density
30102728 Ammonium Nitrate Production, Coating: Low Density
30102801 Normal Superphosphates, Grinding/Drying
30102803 Normal Superphosphates, Rock Unloading
30102823 Normal Superphosphates, Ammoniator/Granulator
30102905 Triple Superphosphate, Run of Pile: Mixer/Den/Curing
30102906 Triple Superphosphate, Granulator: Reactor/Dryer
30102922 Triple Superphosphate, Curing
30102924 Triple Superphosphate, Dryer
30103001 Ammonium Phosphates, Dryers and Coolers
30103002 Ammonium Phosphates, Ammoniator/Granulator
30103004 Ammonium Phosphates, Bagging/Handling
30103023 Ammonium Phosphates, Ammoniator/Granulator
30103024 Ammonium Phosphates, Dryer
30103025 Ammonium Phosphates, Cooler
30103099 Ammonium Phosphates, Other Not Classified
30103101 Terephthalic Acid/Dimethyl Terephthalate, HNO₃ - Para-xylene: General
30103105 Terephthalic Acid/Dimethyl Terephthalate, Product Transfer Vent
30103199 Terephthalic Acid/Dimethyl Terephthalate, Other Not Classified
30103399 Pesticides, Other Not Classified
30103501 Chemical Manufacturing, Inorganic Pigments, TiO₂ Sulfate Process: Calciner
30103503 Inorganic Pigments, TiO₂ Chloride Process: Reactor
30103551 Inorganic Pigments, Ore Dryer
30103552 Inorganic Pigments, Pigment Milling
30103553 Chemical Manufacturing, Inorganic Pigments, Pigment Dryer
30103554 Chemical Manufacturing, Inorganic Pigments, Conveying/Storage/Packing
30103599 Chemical Manufacturing, Inorganic Pigments, Other Not Classified
30103801 Sodium Bicarbonate, General
30104001 Urea Production, General: Specify in Comments
30104002 Urea Production, Solution Concentration (Controlled)
30104003 Urea Production, Prilling
30104004 Urea Production, Drum Granulation
30104006 Urea Production, Bagging
30104007 Urea Production, Bulk Loading
30104008 Urea Production, Non-fluidized Bed Prilling (Agricultural Grade)

AT-A-GLANCE TABLE FOR POINT SOURCES

30104010 Urea Production, Fluidized Bed Prilling (Agricultural Grade)
 30104011 Urea Production, Fluidized Bed Prilling (Feed Grade)
 30104013 Urea Production, Solids Screening
 30104501 Chemical Manufacturing, Organic Fertilizer, General: Mixing/Handling
 30106010 Pharmaceutical Preparations, Storage/Transfer
 30106099 Chemical Manufacturing, Pharmaceutical Preparations, Other Not Classified
 30107001 Inorganic Chemical Manufacturing (General), Fugitive Leaks
 30107002 Chemical Manufacturing, Inorganic Chemical Manufacturing (General), Storage/Transfer
 30112199 Organic Dyes/Pigments, Other Not Classified
 30112501 Chlorine Derivatives, Ethylene Dichloride via Oxychlorination
 30112541 Chlorine Derivatives, Vinyl Chloride: Cracking Furnace
 30112599 Chlorine Derivatives, Other Not Classified
 30112699 Brominated Organics, Bromine Organics
 30113003 Ammonium Sulfate (Use 3-01-210 for Caprolactum Production), Process Vents
 30113004 Ammonium Sulfate (Use 301210 Caprolactum), Caprolactum By-product-Rotary Dryer
 30113221 Organic Acid Manufacturing, General: Acrylic Acid
 30113299 Organic Acid Manufacturing, Other Not Classified
 30115201 Bisphenol A, General
 30116799 Vinyl Acetate, Other Not Classified
 30117601 Glycerin (Glycerol), General
 30118101 Toluene Diisocyanate, General
 30119080 Methyl Methacrylate, Fugitive Emissions
 30119701 Butylene, Ethylene, Propylene, Olefin Production, Ethylene: General
 30121101 Chemical Manufacturing, Linear Alkylbenzene, Olefin Process: General
 30125001 Methanol/Alcohol Production, Methanol: General
 30125010 Methanol/Alcohol Production, Ethanol by Fermentation
 30125099 Methanol/Alcohol Production, Other Not Classified
 30125420 Nitriles, Acrylonitrile, Adiponitrile Production, Fugitive Emissions
 30125499 Nitriles, Acrylonitrile, Adiponitrile Production, Other Not Classified
 30180001 General Processes, Fugitive Leaks
 30181001 General Processes, Air Oxidation Units
 30183001 General Processes, Storage/Transfer
 30184001 General Processes, Distillation Units
 30188801 Chemical Manufacturing, Fugitive Emissions, Specify in Comments Field
 30188802 Fugitive Emissions, Specify in Comments Field
 30188803 Fugitive Emissions, Specify in Comments Field
 30188804 Fugitive Emissions, Specify in Comments Field
 30190003 Fuel Fired Equipment, Natural Gas: Process Heaters
 30190012 Fuel Fired Equipment, Residual Oil: Incinerators
 30190013 Fuel Fired Equipment, Natural Gas: Incinerators
 30190099 Fuel Fired Equipment, Specify in Comments Field
 30199998 Chemical Manufacturing, Other Not Classified, Specify in Comments Field
 30199999 Chemical Manufacturing, Other Not Classified, Specify in Comments Field

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: PM10 control efficiency is 99% from uncontrolled; PM2.5 control efficiency is 95% from uncontrolled

Equipment Life: 20 years

AT-A-GLANCE TABLE FOR POINT SOURCES

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The following are cost ranges for wire-plate ESPs, developed using EPA cost-estimating spreadsheets for dry wire-plate ESPs with adjustments made to reflect wet wire-plate ESPs (EPA, 1999). Capital and operating costs are generally higher due to noncorrosive materials requirements, increased water usage, and treatment and disposal of wet effluent. When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM₁₀ removed were used (Pechan, 2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 1990). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$30 to \$60 per scfm
Typical value is \$40 per scfm

O&M Costs:

Range from \$6 to \$45 per scfm
Typical value is \$19 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for ESP (EPA, 1999). O&M costs were calculated for three model plants with flow rates of 10, 15 and 20 thousand acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust loading of 6.0 grains per cubic feet. The operating time was assumed to be 8640 hours per year. A water flow rate for the ESP was assumed to be 5 gal/min per thousand acfm. The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.067	\$/kW-hr
Process water price	0.20	\$/1000 gal
Dust disposal	20	\$/ton disposed

AT-A-GLANCE TABLE FOR POINT SOURCES

Wastewater treatment 1.5 \$/ thousand gal treated

Note: All costs are in 1995 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$55 to \$550 per ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$220 per ton PM10 reduced. (1995\$)

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

Costs can be substantially higher than in the ranges shown for pollutants which require an unusually high level of control, or which require the ESP to be constructed of special materials such as titanium (EPA, 1999). In most cases, smaller units controlling a low concentration waste stream will not be as cost effective as a large unit cleaning a high pollutant load flow (EPA, 1998).

In the wire-plate ESP, the gas flows around vertical, metal plates. The electrodes are long, weighted wires hanging between the plates. The voltage applied to the electrodes causes the gas between the electrodes to break down, known as a "corona." The electrodes are most often given a negative polarity because a negative corona supports a higher voltage than a positive corona.

Certain types of losses affect control efficiency. The dislodging of the accumulated layer also projects some of the particles back into the gas stream. These particles are processed in later sections of the ESP, but the particles from the last section have no chance to be recaptured. Due to the space needed at the top of the ESP for nonelectrified components, part of the stream may flow around the charged zones. This is called "sneakage" and places an upper limit on the collection efficiency of the ESP. Anti-sneakage baffles are used to force the sneakage flow to mix with the main gas stream for collection in later sections (EPA, 1998).

Wire-Plate Type Wet ESPs require a source of wash water near the top of the collector plates. This wash system replaces the rapping mechanism used by dry ESPs. The water flows with the collected particles into a sump from which the fluid is pumped or drained. A portion of the fluid may be recycled to reduce the total amount of water required. The remainder is pumped into a settling pond or passed through a dewatering stage, with subsequent disposal of the sludge (AWMA, 1992).

Unlike dry ESPs, resistivity of the collected material is not a major factor in performance. Because of the high humidity in a wet ESP, the resistivity of particles is lowered, eliminating the "back corona" condition. The frequent washing of the plates also limits particle buildup on the collectors (EPA, 1998).

For wet ESPs, the handling wastewaters must be considered (EPA, 1999). For simple systems with innocuous dusts, water with particles collected by the ESP may be discharged from the ESP system to a solids-removing clarifier. More complicated systems may require skimming and sludge removal, clarification in dedicated equipment, pH adjustment, and/or treatment to remove dissolved solids. Recirculation of treated water to the ESP may approach 100 percent (AWMA, 1992).

References:

AWMA, 1992: Air & Waste Management Association, Air Pollution Engineering Manual, Van Nostrand Reinhold, New York.

AT-A-GLANCE TABLE FOR POINT SOURCES

EPA, 1996: U.S. EPA, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, EPA 453/B-96-001, Research Triangle Park, NC. February.

EPA, 1998: U.S. EPA, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October.

EPA, 1999: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Wet Electrostatic Precipitator (ESP) - Wire-Plate Type," May 1999

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Chemical Manufacture

Control Measure Name: Increased Monitoring Frequency (IMF) of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P3225

POD: 225

Application: This measure is to conduct improved monitoring for PM_{2.5} emissions at stationary sources. Improved monitoring in this case means increasing the monitoring frequency of electrostatic precipitators, scrubbers, and fabric filters from once per day to four times per hour, with no change in monitoring technique.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (Barr and Schaffner) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

301028** Chemical Manufacturing, Normal Superphosphates
301040** Chemical Manufacturing, Urea Production
301033** Chemical Manufacturing, Pesticides
301030** Chemical Manufacturing, Ammonium Phosphates
301031** Chemical Manufacturing, Terephthalic Acid/Dimethyl Terephthalate
301032** Chemical Manufacturing, Elemental Sulfur Production
301029** Chemical Manufacturing, Triple Superphosphate
301034** Chemical Manufacturing, Aniline/Ethanolamines
301038** Chemical Manufacturing, Sodium Bicarbonate
301091** Chemical Manufacturing, Acetone/Ketone Production
301045** Chemical Manufacturing, Organic Fertilizer
301050** Chemical Manufacturing, Adhesives
301112** Chemical Manufacturing, Elemental Phosphorous
301027** Chemical Manufacturing, Ammonium Nitrate Production
301015** Chemical Manufacturing, Varnish Manufacturing
301060** Chemical Manufacturing, Pharmaceutical Preparations
301070** Chemical Manufacturing, Inorganic Chemical Manufacturing (General)
301111** Chemical Manufacturing, Asbestos Chemical
301100** Chemical Manufacturing, Fluorescent Lamp Manufacture
301035** Chemical Manufacturing, Inorganic Pigments
301820** Chemical Manufacturing, Wastewater Treatment
301001** Chemical Manufacturing, Adipic Acid
301005** Chemical Manufacturing, Carbon Black Production
301006** Chemical Manufacturing, Charcoal Manufacturing
301007** Chemical Manufacturing, Chlorine
301008** Chemical Manufacturing, Chloro-alkali Production

AT-A-GLANCE TABLE FOR POINT SOURCES

301009** Chemical Manufacturing, Cleaning Chemicals
 301010** Chemical Manufacturing, Explosives (Trinitrotoluene)
 301011** Chemical Manufacturing, Hydrochloric Acid
 301012** Chemical Manufacturing, Hydrofluoric Acid
 301017** Chemical Manufacturing, Phosphoric Acid: Thermal Process
 301014** Chemical Manufacturing, Paint Manufacture
 301026** Chemical Manufacturing, Synthetic Rubber (Manufacturing Only)
 301016** Chemical Manufacturing, Phosphoric Acid: Wet Process
 301114** Chemical Manufacturing, Potassium Chloride
 301018** Chemical Manufacturing, Plastics Production
 301019** Chemical Manufacturing, Phthalic Anhydride
 301020** Chemical Manufacturing, Printing Ink Manufacture
 301021** Chemical Manufacturing, Sodium Carbonate
 301023** Chemical Manufacturing, Sulfuric Acid (Contact Process)
 301024** Chemical Manufacturing, Synthetic Organic Fiber Manufacturing
 301025** Chemical Manufacturing, Cellulosic Fiber Production
 301013** Chemical Manufacturing, Nitric Acid
 301810** Chemical Manufacturing, General Processes, Air Oxidation Units
 301800** Chemical Manufacturing, General Processes
 301121** Chemical Manufacturing, Organic Dyes/Pigments
 301999** Chemical Manufacturing, Other Not Classified
 301900** Chemical Manufacturing, Fuel Fired Equipment
 301888** Chemical Manufacturing, Fugitive Emissions
 301840** Chemical Manufacturing, General Processes, Distillation Units
 301830** Chemical Manufacturing, General Processes, Storage/Transfer
 301258** Chemical Manufacturing, Benzene/Toluene/Aromatics/Xylenes
 301254** Chemical Manufacturing, Nitriles, Acrylonitrile, Adiponitrile Production
 301140** Chemical Manufacturing, Acetylene Production
 301125** Chemical Manufacturing, Chlorine Derivatives
 301130** Chemical Manufacturing, Ammonium Sulfate (Use 3-01-210 for Caprolactum Production)
 301132** Chemical Manufacturing, Organic Acid Manufacturing
 301252** Chemical Manufacturing, Etherene Production
 301152** Chemical Manufacturing, Bisphenol A
 301202** Chemical Manufacturing, Phenol
 301210** Chemical Manufacturing, Caprolactum (Use 3-01-130 for Ammonium Sulfate By-product Production)
 301250** Chemical Manufacturing, Methanol/Alcohol Production

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 6.5% for both PM10 and PM2.5

Equipment Life: Not applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs included the incremental record keeping and reporting associated with the increased monitoring frequency. Labor rates for 2003 were made that were obtained from the Bureau of Labor Statistics (labor rates include 140 percent overhead). The incremental costs included a one-time cost for development of the improved

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monitoring and recurring annual burden costs for incremental record keeping, reporting, and certification activities.

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$620 per ton PM reduced (2003\$).

Comments:

Status:

Last Reviewed: 2004

Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM2.5 Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 2003.

BLS, 2003: Bureau of Labor Statistics, "Employer Costs for Employee Compensation – June 2003," Table 12, page 16, 2003.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Chemical Manufacture

Control Measure Name: CEM Upgrade and Increased Monitoring Frequency of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P4225

POD: 225

Application: This measure examines the impacts of improving the PM monitoring technique at units currently using an ESP, scrubber, or fabric filter. In this improved technique scenario, the monitoring technique is upgraded to a PM continuous emission monitor. This improved monitoring technique also results in an increase to the monitoring frequency because a PM CEMS can make a measurement every 7.5 minutes. The monitoring frequency increases from once per day to eight times per hour.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (see References) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

301028** Chemical Manufacturing, Normal Superphosphates
301040** Chemical Manufacturing, Urea Production
301033** Chemical Manufacturing, Pesticides
301030** Chemical Manufacturing, Ammonium Phosphates
301031** Chemical Manufacturing, Terephthalic Acid/Dimethyl Terephthalate
301032** Chemical Manufacturing, Elemental Sulfur Production
301029** Chemical Manufacturing, Triple Superphosphate
301034** Chemical Manufacturing, Aniline/Ethanolamines
301038** Chemical Manufacturing, Sodium Bicarbonate
301091** Chemical Manufacturing, Acetone/Ketone Production
301045** Chemical Manufacturing, Organic Fertilizer
301050** Chemical Manufacturing, Adhesives
301112** Chemical Manufacturing, Elemental Phosphorous
301027** Chemical Manufacturing, Ammonium Nitrate Production
301015** Chemical Manufacturing, Varnish Manufacturing
301060** Chemical Manufacturing, Pharmaceutical Preparations
301070** Chemical Manufacturing, Inorganic Chemical Manufacturing (General)
301111** Chemical Manufacturing, Asbestos Chemical
301100** Chemical Manufacturing, Fluorescent Lamp Manufacture
301035** Chemical Manufacturing, Inorganic Pigments
301820** Chemical Manufacturing, Wastewater Treatment
301001** Chemical Manufacturing, Adipic Acid
301005** Chemical Manufacturing, Carbon Black Production
301006** Chemical Manufacturing, Charcoal Manufacturing

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301007** Chemical Manufacturing, Chlorine
 301008** Chemical Manufacturing, Chloro-alkali Production
 301009** Chemical Manufacturing, Cleaning Chemicals
 301010** Chemical Manufacturing, Explosives (Trinitrotoluene)
 301011** Chemical Manufacturing, Hydrochloric Acid
 301012** Chemical Manufacturing, Hydrofluoric Acid
 301017** Chemical Manufacturing, Phosphoric Acid: Thermal Process
 301014** Chemical Manufacturing, Paint Manufacture
 301026** Chemical Manufacturing, Synthetic Rubber (Manufacturing Only)
 301016** Chemical Manufacturing, Phosphoric Acid: Wet Process
 301114** Chemical Manufacturing, Potassium Chloride
 301018** Chemical Manufacturing, Plastics Production
 301019** Chemical Manufacturing, Phthalic Anhydride
 301020** Chemical Manufacturing, Printing Ink Manufacture
 301021** Chemical Manufacturing, Sodium Carbonate
 301023** Chemical Manufacturing, Sulfuric Acid (Contact Process)
 301024** Chemical Manufacturing, Synthetic Organic Fiber Manufacturing
 301025** Chemical Manufacturing, Cellulosic Fiber Production
 301013** Chemical Manufacturing, Nitric Acid
 301810** Chemical Manufacturing, General Processes, Air Oxidation Units
 301800** Chemical Manufacturing, General Processes
 301121** Chemical Manufacturing, Organic Dyes/Pigments
 301999** Chemical Manufacturing, Other Not Classified
 301900** Chemical Manufacturing, Fuel Fired Equipment
 301888** Chemical Manufacturing, Fugitive Emissions
 301840** Chemical Manufacturing, General Processes, Distillation Units
 301830** Chemical Manufacturing, General Processes, Storage/Transfer
 301258** Chemical Manufacturing, Benzene/Toluene/Aromatics/Xylenes
 301254** Chemical Manufacturing, Nitriles, Acrylonitrile, Adiponitrile Production
 301140** Chemical Manufacturing, Acetylene Production
 301125** Chemical Manufacturing, Chlorine Derivatives
 301130** Chemical Manufacturing, Ammonium Sulfate (Use 3-01-210 for Caprolactum Production)
 301132** Chemical Manufacturing, Organic Acid Manufacturing
 301252** Chemical Manufacturing, Etherene Production
 301152** Chemical Manufacturing, Bisphenol A
 301202** Chemical Manufacturing, Phenol
 301210** Chemical Manufacturing, Caprolactum (Use 3-01-130 for Ammonium Sulfate By-product Production)
 301250** Chemical Manufacturing, Methanol/Alcohol Production

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 7.7% for both PM10 and PM2.5

Equipment Life: Unknown

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The total capital and annual operating costs for implementing an improved monitoring technique are calculated based on data from the EPA CEMS Cost Model and the PM

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CEMS Knowledge document. Labor rates in the EPA CEMS Cost Model are scaled to reflect 2003 labor rates (including 140 percent overhead) provided by the Bureau of Labor Statistics.

The cost effectiveness at a percent excess emission rate of 0.46 percent is \$5,200 per ton of PM_{2.5}. This is based on a \$34 million capital investment cost, and a \$14 million total annualized cost when applied to 128 facilities.

Note: All costs are in 2003 dollars.

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$5,200 per ton PM reduced (2003\$).

Comments:

Status:	Last Reviewed: 2004
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Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM_{2.5} Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 8, 2003.

EPA CEMS Cost Model, Version 3.0, U.S. Environmental Protection Agency.

EPA, 2000: U.S. Environmental Protection Agency, "Current Knowledge of Particulate Matter (PM) Continuous Emissions Monitoring," Chapter 9, PM CEMS Cost, September 8, 2000.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Commercial Institutional Boilers - Coal

Control Measure Name: Fabric Filter (Pulse Jet Type)

Rule Name: Not Applicable

Pechan Measure Code: P2051

POD: 205

Application: This control is the addition of a pulse-jet cleaned fabric filter to reduce PM emissions from waste streams. In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Particulate-laden gas flows into the filter bag from the outside to the inside. The particles collected on the outside drop into a hopper below the fabric filter. During pulse-jet cleaning, a short burst of high pressure air is injected into the bags, dislodging the dust cake.

This control applies to commercial institutional operations with coal-fired boilers.

Affected SCC:

10300101 Anthracite Coal, Pulverized Coal
10300102 Anthracite Coal, Traveling Grate (Overfeed) Stoker
10300205 Bituminous/Subbituminous Coal, Pulverized Coal: Wet Bottom (Bituminous Coal)
10300206 Commercial/Institutional, Pulverized Coal-Dry Bottom (Bituminous Coal)
10300207 Commercial/Institutional, Overfeed Stoker (Bituminous Coal)
10300208 Commercial/Institutional, Underfeed Stoker (Bituminous Coal)
10300209 Commercial/Institutional, Spreader Stoker (Bituminous Coal)
10300217 Commercial/Institutional, Atm. Fluidized Bed Combustion-Bubbling (Bituminous Coal)
10300223 Bituminous/Subbituminous Coal, Cyclone Furnace (Subbituminous Coal)
10300224 Bituminous/Subbituminous Coal, Spreader Stoker (Subbituminous Coal)
10300225 Bituminous/Subbituminous Coal, Traveling Grate (Overfeed) Stoker (Subbituminous)
10300309 Lignite, Spreader Stoker

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 99% from uncontrolled for both PM10 and PM2.5

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs for pulse-jet cleaned systems are generated using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan,2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 2000). Total installed capital costs were annualized using a capital recovery factor, with is based

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on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$6 to \$26 per scfm
Typical value is \$13 per scfm

O&M Costs:

Range from \$5 to \$24 per scfm
Typical value is \$11 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). O&M costs were calculated for three model plants with flow rates of 25, 75 and 150 thousand acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust loading of 4.0 grains per cubic feet. The operating time was assumed to be 8760 hours per year. An average bag cost was estimated using the costs for standard bag types. Capital recovery for the periodic replacement of bags was included in the O&M cost of the bags using a bag life of 2 years (EPA, 1998a). The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.0671	\$/kW-hr
Compressed air	0.25	\$/1000 scf
Dust disposal	25	\$/ton disposed

Note: All costs are in 1998 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$42 to \$266 per ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$117 per ton PM10 reduced. (1998\$)

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

The cost estimates assume a conventional design under typical operating conditions and do not include auxiliary equipment such as fans and ductwork. The costs for pulse-jet cleaned systems are generated using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a).

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Costs are primarily based on volumetric flow rate and the amount of PM in the waste stream. In general, a small unit controlling a low pollutant levels will not be as cost effective as a large unit controlling a high pollutant levels. (EPA, 2000)

Pollutants requiring a high level of control or the fabric filters to be constructed of special materials will increase the costs of the system (EPA, 1998a). The additional costs for controlling complex waste streams are not included in the estimates. For these systems, the capital cost could increase by as much as 75% and the operational and maintenance (O&M) cost could increase by as much as 20% (EPA, 2000).

In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Fabric filters may be in the form of sheets, cartridges, or bags, with many individual filter units together in a group. Bags are the most common type of filter. The dust cake that forms on the filter from the collected PM can significantly increase collection efficiency. (EPA, 2000)

Pulse-jet cleaning of fabric filters is a relatively new type of fabric filter, as they have only been used for the past 30 years. This cleaning mechanism has grown in popularity because it can treat high dust loadings, operate at constant pressure drop, and occupy less space than other types of fabric filters (EPA, 2000). Particulate-laden gas flows into the bag. The gas flows from the outside to the inside of the bags, and then out the gas exhaust. The particles collected on the outside drop into a hopper below the fabric filter (EPA, 1998b).

During pulse-jet cleaning, a short burst of high pressure air is injected into the bags (EPA, 1998b). The pulse is blown through a venturi nozzle at the top of the bags and establishes a shock wave that continues onto the bottom of the bag. The wave flexes the fabric dislodging the dust cake.

There are several unique attributes of pulse-jet cleaning. The cleaning pulse is very brief allowing the flow of dusty gas to continue during cleaning. The bags not being cleaned continue to filter, taking on extra duty from the bags being cleaned (EPA, 2000). Pulse-jet cleaning is more intense and occurs with greater frequency than the other fabric filter cleaning methods. The cleaning dislodges nearly all of the dust cake each time the bag is pulsed. Pulse-jet filters, as a result, do not rely on a dust cake to provide filtration. Felted (non-woven) fabrics are used in these types of filters because they do not require a dust cake. Also it has been found that woven fabrics used with pulse-jet cleaning leak dust after they are cleaned (EPA, 1998b).

Since bags cleaned by the pulse-jet method do not need to be isolated for cleaning, pulsejet cleaned fabric filters do not need extra compartments to maintain adequate filtration during cleaning. Also, because of the intense and frequent nature of the cleaning, they can treat higher gas flow rates with higher dust loadings. Consequently, fabric filters cleaned by the pulse-jet method can be smaller than other filters in the treatment of the same amount of gas and dust, making higher gas-to-cloth ratios achievable (EPA, 1998b).

Fabric filters are useful for collecting particles with resistivities either too low or too high for collection with electrostatic precipitators. Fabric filters are useful in controlling particulate matter less than or equal to 10 micrometers (μm) in diameter (PM₁₀) and particulate matter less than or equal to 2.5 μm in diameter (PM_{2.5}). Fabric filters may be good candidates for collecting fly ash from low-sulfur coals or containing high unburned carbon levels and are relatively difficult to collect with electrostatic precipitators. (EPA, 2000)

AT-A-GLANCE TABLE FOR POINT SOURCES

References:

EPA, 1998a: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, Chapter 5, EPA 453/B-96-001, Research Triangle Park, NC. December 1998.

EPA, 1998b: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

EPA, 2000: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Fabric Filter - Pulse-Jet Cleaned Type," April 2000.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Commercial Institutional Boilers - Coal

Control Measure Name: Dry ESP-Wire Plate Type

Rule Name: Not Applicable

Pechan Measure Code: P2052

POD: 205

Application: This control is the use of dry electrostatic precipitators (ESP) to reduce PM emissions. An ESP uses electrical forces to move particles in an exhaust stream onto collector plates. Electrodes in the center of the flow are maintained at high voltage and generate an electrical field forcing particles to the collector walls. In dry ESPs, the collectors are knocked by various mechanical means to dislodge the particulate, which slides downward into a hopper.

This control applies to point sources with coal-fired boilers.

Affected SCC:

10300101 Anthracite Coal, Pulverized Coal
10300102 Anthracite Coal, Traveling Grate (Overfeed) Stoker
10300205 Bituminous/Subbituminous Coal, Pulverized Coal: Wet Bottom (Bituminous Coal)
10300206 Commercial/Institutional, Pulverized Coal-Dry Bottom (Bituminous Coal)
10300207 Commercial/Institutional, Overfeed Stoker (Bituminous Coal)
10300208 Commercial/Institutional, Underfeed Stoker (Bituminous Coal)
10300209 Commercial/Institutional, Spreader Stoker (Bituminous Coal)
10300217 Commercial/Institutional, Atm. Fluidized Bed Combustion-Bubbling (Bituminous Coal)
10300224 Bituminous/Subbituminous Coal, Spreader Stoker (Subbituminous Coal)
10300225 Bituminous/Subbituminous Coal, Traveling Grate (Overfeed) Stoker (Subbituminous)
10300309 Lignite, Spreader Stoker

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: PM10 control efficiency is 98% from uncontrolled; PM2.5 control efficiency is 95% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs for ESPs of conventional design under typical operating conditions are developed using EPA cost estimating spreadsheets (EPA, 1996). When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan, 2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 1999). Total installed capital costs were annualized using a capital recovery factor, with is based

AT-A-GLANCE TABLE FOR POINT SOURCES

on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$15 to \$50 per scfm
Typical value is \$27 per scfm

O&M Costs:

Range from \$4 to \$40 per scfm
Typical value is \$16 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for ESP (EPA, 1996). O&M costs were calculated for three model plants with flow rates of 200 and 500 thousand acfm and 1 million acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust loading of 6.0 grains per cubic feet. The operating time was assumed to be 8640 hours per year. The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.067	\$/kW-hr
Dust disposal	25	\$/ton disposed

Note: All costs are in 1995 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$40 to \$250 per ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$110 per ton PM10 reduced. (1995\$)

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

In the wire-plate ESP, the gas flows around vertical, metal plates. The electrodes are long, weighted wires hanging between the plates. The voltage applied to the electrodes causes the gas between the electrodes to break down, known as a "corona." The electrodes are most often given a negative polarity because a negative corona supports a higher voltage than a positive corona.

Certain types of losses affect control efficiency. The dislodging of the accumulated layer also projects some of the particles back into the gas stream. These particles are processed in later

AT-A-GLANCE TABLE FOR POINT SOURCES

sections of the ESP, but the particles from the last section have no chance to be recaptured. Due to the space needed at the top of the ESP for nonelectrified components, part of the stream may flow around the charged zones. This is called "sneakage" and places an upper limit on the collection efficiency of the ESP. Anti-sneakage baffles are used to force the sneakage flow to mix with the main gas stream for collection in later sections (EPA, 1998).

Another factor in the performance of ESPs is the resistivity of the collected material. All the ion current must pass through the collected layer to reach the ground plates. This creates an electric field in the layer, and it can become large enough to cause electrical breakdown. When this occurs, new ions of the wrong polarity are injected into the wire-plate gap reducing the charge on the particles, which may cause sparking. This condition is called "back corona." When this happens the collection ability of the unit is reduced. At low resistivities the particles are held on the plates so loosely that reentrainment levels are much higher. Hence, care must be taken in measuring or estimating resistivity because it is strongly affected by such variables as temperature, moisture, gas composition, particle composition, and surface characteristics (EPA, 1999).

Dusts with high resistivities are also not well-suited for collection in dry ESPs. These particles are not easily charged nor easily collected. High-resistivity particles form ash layers with very high voltage gradients on the collecting electrodes lead to back corona, reducing the charge on particles and lowering collection efficiency. Fly ash from the combustion of low-sulfur coal typically has a high resistivity, and thus is difficult to collect using dry ESPs (EPA, 1999).

References:

EPA, 1996: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, EPA 453/B-96-001, Research Triangle Park, NC. February 1996.

EPA, 1998: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

EPA, 1999: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Dry Electrostatic Precipitator (ESP) - Wire-Plate Type," May 1999.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

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Source Category: Commercial Institutional Boilers - Coal

Control Measure Name: Fabric Filter (Reverse-Air Cleaned Type)

Rule Name: Not Applicable

Pechan Measure Code: P2053

POD: 205

Application: This control is the use of a reverse-air cleaned fabric filter to reduce PM emissions from waste streams. In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Reverse-air cleaning is performed by forcing clean air through the filters in the opposite direction of the dusty gas flow. The change in direction of the gas flow causes the bag to flex and crack the filter cake allowing for internal cake collection.

This control applies to commercial industrial operations with coal-fired boilers.

Affected SCC:

10300101 Anthracite Coal, Pulverized Coal
10300102 Anthracite Coal, Traveling Grate (Overfeed) Stoker
10300205 Bituminous/Subbituminous Coal, Pulverized Coal: Wet Bottom (Bituminous Coal)
10300206 Commercial/Institutional, Pulverized Coal-Dry Bottom (Bituminous Coal)
10300207 Commercial/Institutional, Overfeed Stoker (Bituminous Coal)
10300208 Commercial/Institutional, Underfeed Stoker (Bituminous Coal)
10300209 Commercial/Institutional, Spreader Stoker (Bituminous Coal)
10300217 Commercial/Institutional, Atm. Fluidized Bed Combustion-Bubbling (Bituminous Coal)
10300223 Bituminous/Subbituminous Coal, Cyclone Furnace (Subbituminous Coal)
10300224 Bituminous/Subbituminous Coal, Spreader Stoker (Subbituminous Coal)
10300225 Bituminous/Subbituminous Coal, Traveling Grate (Overfeed) Stoker (Subbituminous)
10300309 Lignite, Spreader Stoker

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 99% from uncontrolled for both PM10 and PM2.5

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs for reverse-air cleaned systems are generated using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan,2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 2000). Total installed capital costs were annualized using a capital recovery factor, with is based

AT-A-GLANCE TABLE FOR POINT SOURCES

on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$9 to \$84 per scfm
Typical value is \$34 per scfm

O&M Costs:

Range from \$6 to \$27 per scfm
Typical value is \$13 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). O&M costs were calculated for three model plants with flow rates of 25, 75 and 150 thousand acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust loading of 4.0 grains per cubic feet. The operating time was assumed to be 8760 hours per year. An average bag cost was estimated using the costs for standard bag types. Capital recovery for the periodic replacement of bags was included in the O&M cost of the bags using a bag life of 2 years (EPA, 1998a). The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.0671	\$/kW-hr
Compressed air	0.25	\$/1000 scf
Dust disposal	25	\$/ton disposed

Note: All costs are in 1998 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$53 to \$337 per ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$148 per ton PM10 reduced. (1998\$)

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

The cost estimates assume a conventional design under typical operating conditions. The costs do not include any auxiliary equipment (EPA, 2000).

The capital cost for the reverse-jet cleaned fabric baghouse is based on information provided by a

AT-A-GLANCE TABLE FOR POINT SOURCES

manufacturer (EPA, 2000). The capital cost includes only the purchased equipment cost.

Costs are primarily based on volumetric flow rate and the amount of PM in the waste stream. In general, a small unit controlling a low pollutant levels will not be as cost effective as a large unit controlling a high pollutant levels. (EPA, 2000)

Pollutants requiring a high level of control or the fabric filters to be constructed of special materials will increase the costs of the system (EPA, 1998a). The additional costs for controlling complex streams are not reflected in the estimates. For these systems, the capital cost could increase by as much as 40% and the O&M cost could increase by as much as 5%. (EPA, 2000)

In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Fabric filters may be in the form of sheets, cartridges, or bags, with many individual filter units together in a group. Bags are the most common type of filter. The dust cake that forms on the filter from the collected PM can significantly increase collection efficiency. (EPA, 2000)

Reverse-air cleaning is a popular filter cleaning method as it has been used extensively and improved over the years. It is a gentler but sometimes less effective clearing mechanism than mechanical shaking. Reverse-air cleaning is performed by forcing clean air through the filters in the opposite direction of the dusty gas flow. The change in direction of the gas flow causes the bag to flex and crack the filter cake allowing for internal cake collection (EPA, 2000).

The most common design is to have separate compartments within the fabric filter so that each can be isolated and cleaned separately while the others continue to treat the dusty gas. There are several methods of reversing the flow through the filters. One method of providing the reverse flow is by the use of a fan or cleaned gas from other compartments. Reverse-air cleaning only used alone in cases where the dust releases easily from the fabric. In many instances, reverse-air is used along with shaking, pulsing or sonic horns (EPA, 1998b).

Fabric filters are useful for collecting particles with resistivities either too low or too high for collection with electrostatic precipitators. Fabric filters are useful in controlling particulate matter less than or equal to 10 micrometers (μm) in diameter (PM₁₀) and particulate matter less than or equal to 2.5 μm in diameter (PM_{2.5}). Fabric filters may be good candidates for collecting fly ash from low-sulfur coals or containing high unburned carbon levels and are relatively difficult to collect with electrostatic precipitators. (EPA, 2000)

References:

EPA, 1998b: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

EPA, 1998a: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, Chapter 5, EPA 453/B-96-001, Research Triangle Park, NC. December 1998.

EPA, 2000: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Fabric Filter - Reverse-Air Cleaned Type," April 2000.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Commercial Institutional Boilers - Coal

Control Measure Name: Increased Monitoring Frequency (IMF) of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P3205

POD: 205

Application: This measure is to conduct improved monitoring for PM_{2.5} emissions at stationary sources. Improved monitoring in this case means increasing the monitoring frequency of electrostatic precipitators, scrubbers, and fabric filters from once per day to four times per hour, with no change in monitoring technique.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (Barr and Schaffner) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

103001** Anthracite Coal, Pulverized Coal

103002** Bituminous/Subbituminous Coal, Pulverized Coal

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 6.5% for both PM₁₀ and PM_{2.5}

Equipment Life: Not applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs included the incremental record keeping and reporting associated with the increased monitoring frequency. Labor rates for 2003 were made that were obtained from the Bureau of Labor Statistics (labor rates include 140 percent overhead). The incremental costs included a one-time cost for development of the improved monitoring and recurring annual burden costs for incremental record keeping, reporting, and certification activities.

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$620 per ton PM reduced (2003\$).

Comments:

Status:

Last Reviewed: 2004

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM2.5 Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 2003.

BLS, 2003: Bureau of Labor Statistics, "Employer Costs for Employee Compensation – June 2003," Table 12, page 16, 2003.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Commercial Institutional Boilers - Coal

Control Measure Name: CEM Upgrade and Increased Monitoring Frequency of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P4205

POD: 205

Application: This measure examines the impacts of improving the PM monitoring technique at units currently using an ESP, scrubber, or fabric filter. In this improved technique scenario, the monitoring technique is upgraded to a PM continuous emission monitor. This improved monitoring technique also results in an increase to the monitoring frequency because a PM CEMS can make a measurement every 7.5 minutes. The monitoring frequency increases from once per day to eight times per hour.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (see References) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

103001** Anthracite Coal, Pulverized Coal

103002** Bituminous/Subbituminous Coal, Pulverized Coal

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 7.7% for both PM10 and PM2.5

Equipment Life: Unknown

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The total capital and annual operating costs for implementing an improved monitoring technique are calculated based on data from the EPA CEMS Cost Model and the PM CEMS Knowledge document. Labor rates in the EPA CEMS Cost Model are scaled to reflect 2003 labor rates (including 140 percent overhead) provided by the Bureau of Labor Statistics.

The cost effectiveness at a percent excess emission rate of 0.46 percent is \$5,200 per ton of PM2.5. This is based on a \$34 million capital investment cost, and a \$14 million total annualized cost when applied to 128 facilities.

Note: All costs are in 2003 dollars.

AT-A-GLANCE TABLE FOR POINT SOURCES

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$5,200 per ton PM reduced (2003\$).

Comments:

Status:

Last Reviewed: 2004

Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM_{2.5} Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 8, 2003.

EPA CEMS Cost Model, Version 3.0, U.S. Environmental Protection Agency.

EPA, 2000: U.S. Environmental Protection Agency, "Current Knowledge of Particulate Matter (PM) Continuous Emissions Monitoring," Chapter 9, PM CEMS Cost, September 8, 2000.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Commercial Institutional Boilers - Liquid Waste

Control Measure Name: Increased Monitoring Frequency (IMF) of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P3228

POD: 228

Application: This measure is to conduct improved monitoring for PM_{2.5} emissions at stationary sources. Improved monitoring in this case means increasing the monitoring frequency of electrostatic precipitators, scrubbers, and fabric filters from once per day to four times per hour, with no change in monitoring technique.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (Barr and Schaffner) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

103013** Commercial/Institutional, Liquid Waste

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 6.5% for both PM₁₀ and PM_{2.5}

Equipment Life: Not applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs included the incremental record keeping and reporting associated with the increased monitoring frequency. Labor rates for 2003 were made that were obtained from the Bureau of Labor Statistics (labor rates include 140 percent overhead). The incremental costs included a one-time cost for development of the improved monitoring and recurring annual burden costs for incremental record keeping, reporting, and certification activities.

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$620 per ton PM reduced (2003\$).

Comments:

Status:

Last Reviewed: 2004

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM2.5 Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 2003.

BLS, 2003: Bureau of Labor Statistics, "Employer Costs for Employee Compensation – June 2003," Table 12, page 16, 2003.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Commercial Institutional Boilers - Liquid Waste

Control Measure Name: CEM Upgrade and Increased Monitoring Frequency of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P4228

POD: 228

Application: This measure examines the impacts of improving the PM monitoring technique at units currently using an ESP, scrubber, or fabric filter. In this improved technique scenario, the monitoring technique is upgraded to a PM continuous emission monitor. This improved monitoring technique also results in an increase to the monitoring frequency because a PM CEMS can make a measurement every 7.5 minutes. The monitoring frequency increases from once per day to eight times per hour.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (see References) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

103013** Commercial/Institutional, Liquid Waste

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 7.7% for both PM10 and PM2.5

Equipment Life: Unknown

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The total capital and annual operating costs for implementing an improved monitoring technique are calculated based on data from the EPA CEMS Cost Model and the PM CEMS Knowledge document. Labor rates in the EPA CEMS Cost Model are scaled to reflect 2003 labor rates (including 140 percent overhead) provided by the Bureau of Labor Statistics.

The cost effectiveness at a percent excess emission rate of 0.46 percent is \$5,200 per ton of PM2.5. This is based on a \$34 million capital investment cost, and a \$14 million total annualized cost when applied to 128 facilities.

Note: All costs are in 2003 dollars.

AT-A-GLANCE TABLE FOR POINT SOURCES

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$5,200 per ton PM reduced (2003\$).

Comments:

Status:

Last Reviewed: 2004

Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM_{2.5} Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 8, 2003.

EPA CEMS Cost Model, Version 3.0, U.S. Environmental Protection Agency.

EPA, 2000: U.S. Environmental Protection Agency, "Current Knowledge of Particulate Matter (PM) Continuous Emissions Monitoring," Chapter 9, PM CEMS Cost, September 8, 2000.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Commercial Institutional Boilers - LPG

Control Measure Name: Increased Monitoring Frequency (IMF) of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P3227

POD: 227

Application: This measure is to conduct improved monitoring for PM_{2.5} emissions at stationary sources. Improved monitoring in this case means increasing the monitoring frequency of electrostatic precipitators, scrubbers, and fabric filters from once per day to four times per hour, with no change in monitoring technique.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (Barr and Schaffner) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

103010** Commercial/Institutional, Liquified Petroleum Gas (LPG)

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 6.5% for both PM₁₀ and PM_{2.5}

Equipment Life: Not applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs included the incremental record keeping and reporting associated with the increased monitoring frequency. Labor rates for 2003 were made that were obtained from the Bureau of Labor Statistics (labor rates include 140 percent overhead). The incremental costs included a one-time cost for development of the improved monitoring and recurring annual burden costs for incremental record keeping, reporting, and certification activities.

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$620 per ton PM reduced (2003\$).

Comments:

Status:

Last Reviewed: 2004

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM2.5 Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 2003.

BLS, 2003: Bureau of Labor Statistics, "Employer Costs for Employee Compensation – June 2003," Table 12, page 16, 2003.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Commercial Institutional Boilers - LPG

Control Measure Name: CEM Upgrade and Increased Monitoring Frequency of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P4227

POD: 227

Application: This measure examines the impacts of improving the PM monitoring technique at units currently using an ESP, scrubber, or fabric filter. In this improved technique scenario, the monitoring technique is upgraded to a PM continuous emission monitor. This improved monitoring technique also results in an increase to the monitoring frequency because a PM CEMS can make a measurement every 7.5 minutes. The monitoring frequency increases from once per day to eight times per hour.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (see References) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

103010** Commercial/Institutional, Liquified Petroleum Gas (LPG)

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 7.7% for both PM10 and PM2.5

Equipment Life: Unknown

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The total capital and annual operating costs for implementing an improved monitoring technique are calculated based on data from the EPA CEMS Cost Model and the PM CEMS Knowledge document. Labor rates in the EPA CEMS Cost Model are scaled to reflect 2003 labor rates (including 140 percent overhead) provided by the Bureau of Labor Statistics.

The cost effectiveness at a percent excess emission rate of 0.46 percent is \$5,200 per ton of PM2.5. This is based on a \$34 million capital investment cost, and a \$14 million total annualized cost when applied to 128 facilities.

Note: All costs are in 2003 dollars.

AT-A-GLANCE TABLE FOR POINT SOURCES

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$5,200 per ton PM reduced (2003\$).

Comments:

Status:

Last Reviewed: 2004

Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM_{2.5} Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 8, 2003.

EPA CEMS Cost Model, Version 3.0, U.S. Environmental Protection Agency.

EPA, 2000: U.S. Environmental Protection Agency, "Current Knowledge of Particulate Matter (PM) Continuous Emissions Monitoring," Chapter 9, PM CEMS Cost, September 8, 2000.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Commercial Institutional Boilers - Natural Gas

Control Measure Name: Increased Monitoring Frequency (IMF) of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P3229

POD: 229

Application: This measure is to conduct improved monitoring for PM_{2.5} emissions at stationary sources. Improved monitoring in this case means increasing the monitoring frequency of electrostatic precipitators, scrubbers, and fabric filters from once per day to four times per hour, with no change in monitoring technique.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (Barr and Schaffner) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

103006** Commercial/Institutional, Natural Gas

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 6.5% for both PM₁₀ and PM_{2.5}

Equipment Life: Not applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs included the incremental record keeping and reporting associated with the increased monitoring frequency. Labor rates for 2003 were made that were obtained from the Bureau of Labor Statistics (labor rates include 140 percent overhead). The incremental costs included a one-time cost for development of the improved monitoring and recurring annual burden costs for incremental record keeping, reporting, and certification activities.

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$620 per ton PM reduced (2003\$).

Comments:

Status:

Last Reviewed: 2004

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM2.5 Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 2003.

BLS, 2003: Bureau of Labor Statistics, "Employer Costs for Employee Compensation – June 2003," Table 12, page 16, 2003.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Commercial Institutional Boilers - Natural Gas

Control Measure Name: CEM Upgrade and Increased Monitoring Frequency of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P4229

POD: 229

Application: This measure examines the impacts of improving the PM monitoring technique at units currently using an ESP, scrubber, or fabric filter. In this improved technique scenario, the monitoring technique is upgraded to a PM continuous emission monitor. This improved monitoring technique also results in an increase to the monitoring frequency because a PM CEMS can make a measurement every 7.5 minutes. The monitoring frequency increases from once per day to eight times per hour.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (see References) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

103006** Commercial/Institutional, Natural Gas

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 7.7% for both PM10 and PM2.5

Equipment Life: Unknown

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The total capital and annual operating costs for implementing an improved monitoring technique are calculated based on data from the EPA CEMS Cost Model and the PM CEMS Knowledge document. Labor rates in the EPA CEMS Cost Model are scaled to reflect 2003 labor rates (including 140 percent overhead) provided by the Bureau of Labor Statistics.

The cost effectiveness at a percent excess emission rate of 0.46 percent is \$5,200 per ton of PM2.5. This is based on a \$34 million capital investment cost, and a \$14 million total annualized cost when applied to 128 facilities.

Note: All costs are in 2003 dollars.

AT-A-GLANCE TABLE FOR POINT SOURCES

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$5,200 per ton PM reduced (2003\$).

Comments:

Status:

Last Reviewed: 2004

Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM_{2.5} Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 8, 2003.

EPA CEMS Cost Model, Version 3.0, U.S. Environmental Protection Agency.

EPA, 2000: U.S. Environmental Protection Agency, "Current Knowledge of Particulate Matter (PM) Continuous Emissions Monitoring," Chapter 9, PM CEMS Cost, September 8, 2000.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Commercial Institutional Boilers - Oil

Control Measure Name: Dry ESP-Wire Plate Type

Rule Name: Not Applicable

Pechan Measure Code: P2071

POD: 207

Application: This control is the use of dry electrostatic precipitators (ESP) to reduce PM emissions. An ESP uses electrical forces to move particles in an exhaust stream onto collector plates. Electrodes in the center of the flow are maintained at high voltage and generate an electrical field forcing particles to the collector walls. In dry ESPs, the collectors are knocked by various mechanical means to dislodge the particulate, which slides downward into a hopper.

This control applies to point sources with oil-fired boilers.

Affected SCC:

10300401 Commercial/Institutional, Residual Oil, Grade 6 Oil

10300403 Residual Oil, < 10 Million Btu/hr **

10300501 Commercial/Institutional, Distillate Oil, Grades 1 and 2 Oil

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: PM10 control efficiency is 98% from uncontrolled; PM2.5 control efficiency is 95% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs for ESPs of conventional design under typical operating conditions are developed using EPA cost estimating spreadsheets (EPA, 1996). When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan, 2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 1999). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of

AT-A-GLANCE TABLE FOR POINT SOURCES

equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$15 to \$50 per scfm
Typical value is \$27 per scfm

O&M Costs:

Range from \$4 to \$40 per scfm
Typical value is \$16 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for ESP (EPA, 1996). O&M costs were calculated for three model plants with flow rates of 200 and 500 thousand acfm and 1 million acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust loading of 6.0 grains per cubic feet. The operating time was assumed to be 8640 hours per year. The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.067	\$/kW-hr
Dust disposal	25	\$/ton disposed

Note: All costs are in 1995 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$40 to \$250 per ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$110 per ton PM10 reduced. (1995\$)

Comments:

Status: Demonstrated	Last Reviewed: 2001
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Additional Information:

In the wire-plate ESP, the gas flows around vertical, metal plates. The electrodes are long, weighted wires hanging between the plates. The voltage applied to the electrodes causes the gas between the electrodes to break down, known as a "corona." The electrodes are most often given a negative polarity because a negative corona supports a higher voltage than a positive corona.

Certain types of losses affect control efficiency. The dislodging of the accumulated layer also projects some of the particles back into the gas stream. These particles are processed in later sections of the ESP, but the particles from the last section have no chance to be recaptured. Due to the space needed at the top of the ESP for nonelectrified components, part of the stream may flow around the charged zones. This is called "sneakage" and places an upper limit on the collection efficiency of the ESP. Anti-sneakage baffles are used to force the sneakage flow to mix with the main gas stream for collection in later sections (EPA, 1998).

Another factor in the performance of ESPs is the resistivity of the collected material. All the ion current must pass through the collected layer to reach the ground plates. This creates an electric

AT-A-GLANCE TABLE FOR POINT SOURCES

field in the layer, and it can become large enough to cause electrical breakdown. When this occurs, new ions of the wrong polarity are injected into the wire-plate gap reducing the charge on the particles, which may cause sparking. This condition is called "back corona." When this happens the collection ability of the unit is reduced. At low resistivities the particles are held on the plates so loosely that reentrainment levels are much higher. Hence, care must be taken in measuring or estimating resistivity because it is strongly affected by such variables as temperature, moisture, gas composition, particle composition, and surface characteristics (EPA, 1999).

Dusts with high resistivities are also not well-suited for collection in dry ESPs. These particles are not easily charged nor easily collected. High-resistivity particles form ash layers with very high voltage gradients on the collecting electrodes lead to back corona, reducing the charge on particles and lowering collection efficiency. Fly ash from the combustion of low-sulfur coal typically has a high resistivity, and thus is difficult to collect using dry ESPs (EPA, 1999).

References:

EPA, 1996: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, EPA 453/B-96-001, Research Triangle Park, NC. February 1996.

EPA, 1998: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

EPA, 1999: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Dry Electrostatic Precipitator (ESP) - Wire-Plate Type," May 1999.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Commercial Institutional Boilers - Oil

Control Measure Name: Increased Monitoring Frequency (IMF) of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P3207

POD: 207

Application: This measure is to conduct improved monitoring for PM_{2.5} emissions at stationary sources. Improved monitoring in this case means increasing the monitoring frequency of electrostatic precipitators, scrubbers, and fabric filters from once per day to four times per hour, with no change in monitoring technique.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (Barr and Schaffner) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

103004** Commercial/Institutional, Residual Oil

103005** Commercial/Institutional, Distillate Oil

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 6.5% for both PM₁₀ and PM_{2.5}

Equipment Life: Not applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs included the incremental record keeping and reporting associated with the increased monitoring frequency. Labor rates for 2003 were made that were obtained from the Bureau of Labor Statistics (labor rates include 140 percent overhead). The incremental costs included a one-time cost for development of the improved monitoring and recurring annual burden costs for incremental record keeping, reporting, and certification activities.

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$620 per ton PM reduced (2003\$).

Comments:

Status:

Last Reviewed: 2004

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM2.5 Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 2003.

BLS, 2003: Bureau of Labor Statistics, "Employer Costs for Employee Compensation – June 2003," Table 12, page 16, 2003.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Commercial Institutional Boilers - Oil

Control Measure Name: CEM Upgrade and Increased Monitoring Frequency of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P4207

POD: 207

Application: This measure examines the impacts of improving the PM monitoring technique at units currently using an ESP, scrubber, or fabric filter. In this improved technique scenario, the monitoring technique is upgraded to a PM continuous emission monitor. This improved monitoring technique also results in an increase to the monitoring frequency because a PM CEMS can make a measurement every 7.5 minutes. The monitoring frequency increases from once per day to eight times per hour.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (see References) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

103004** Commercial/Institutional, Residual Oil

103005** Commercial/Institutional, Distillate Oil

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 7.7% for both PM10 and PM2.5

Equipment Life: Unknown

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The total capital and annual operating costs for implementing an improved monitoring technique are calculated based on data from the EPA CEMS Cost Model and the PM CEMS Knowledge document. Labor rates in the EPA CEMS Cost Model are scaled to reflect 2003 labor rates (including 140 percent overhead) provided by the Bureau of Labor Statistics.

The cost effectiveness at a percent excess emission rate of 0.46 percent is \$5,200 per ton of PM2.5. This is based on a \$34 million capital investment cost, and a \$14 million total annualized cost when applied to 128 facilities.

Note: All costs are in 2003 dollars.

AT-A-GLANCE TABLE FOR POINT SOURCES

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$5,200 per ton PM reduced (2003\$).

Comments:

Status:

Last Reviewed: 2004

Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM_{2.5} Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 8, 2003.

EPA CEMS Cost Model, Version 3.0, U.S. Environmental Protection Agency.

EPA, 2000: U.S. Environmental Protection Agency, "Current Knowledge of Particulate Matter (PM) Continuous Emissions Monitoring," Chapter 9, PM CEMS Cost, September 8, 2000.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Commercial Institutional Boilers - Process Gas

Control Measure Name: Increased Monitoring Frequency (IMF) of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P3230

POD: 230

Application: This measure is to conduct improved monitoring for PM_{2.5} emissions at stationary sources. Improved monitoring in this case means increasing the monitoring frequency of electrostatic precipitators, scrubbers, and fabric filters from once per day to four times per hour, with no change in monitoring technique.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (Barr and Schaffner) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

103007** Commercial/Institutional, Process Gas

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 6.5% for both PM₁₀ and PM_{2.5}

Equipment Life: Not applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs included the incremental record keeping and reporting associated with the increased monitoring frequency. Labor rates for 2003 were made that were obtained from the Bureau of Labor Statistics (labor rates include 140 percent overhead). The incremental costs included a one-time cost for development of the improved monitoring and recurring annual burden costs for incremental record keeping, reporting, and certification activities.

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$620 per ton PM reduced (2003\$).

Comments:

Status:

Last Reviewed: 2004

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM2.5 Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 2003.

BLS, 2003: Bureau of Labor Statistics, "Employer Costs for Employee Compensation – June 2003," Table 12, page 16, 2003.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Commercial Institutional Boilers - Process Gas

Control Measure Name: CEM Upgrade and Increased Monitoring Frequency of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P4230

POD: 230

Application: This measure examines the impacts of improving the PM monitoring technique at units currently using an ESP, scrubber, or fabric filter. In this improved technique scenario, the monitoring technique is upgraded to a PM continuous emission monitor. This improved monitoring technique also results in an increase to the monitoring frequency because a PM CEMS can make a measurement every 7.5 minutes. The monitoring frequency increases from once per day to eight times per hour.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (see References) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

103007** Commercial/Institutional, Process Gas

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 7.7% for both PM10 and PM2.5

Equipment Life: Unknown

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The total capital and annual operating costs for implementing an improved monitoring technique are calculated based on data from the EPA CEMS Cost Model and the PM CEMS Knowledge document. Labor rates in the EPA CEMS Cost Model are scaled to reflect 2003 labor rates (including 140 percent overhead) provided by the Bureau of Labor Statistics.

The cost effectiveness at a percent excess emission rate of 0.46 percent is \$5,200 per ton of PM2.5. This is based on a \$34 million capital investment cost, and a \$14 million total annualized cost when applied to 128 facilities.

Note: All costs are in 2003 dollars.

AT-A-GLANCE TABLE FOR POINT SOURCES

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$5,200 per ton PM reduced (2003\$).

Comments:

Status:

Last Reviewed: 2004

Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM_{2.5} Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 8, 2003.

EPA CEMS Cost Model, Version 3.0, U.S. Environmental Protection Agency.

EPA, 2000: U.S. Environmental Protection Agency, "Current Knowledge of Particulate Matter (PM) Continuous Emissions Monitoring," Chapter 9, PM CEMS Cost, September 8, 2000.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Commercial Institutional Boilers - Solid Waste

Control Measure Name: Increased Monitoring Frequency (IMF) of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P3231

POD: 231

Application: This measure is to conduct improved monitoring for PM_{2.5} emissions at stationary sources. Improved monitoring in this case means increasing the monitoring frequency of electrostatic precipitators, scrubbers, and fabric filters from once per day to four times per hour, with no change in monitoring technique.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (Barr and Schaffner) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

103012** Commercial/Institutional, Solid Waste

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 6.5% for both PM₁₀ and PM_{2.5}

Equipment Life: Not applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs included the incremental record keeping and reporting associated with the increased monitoring frequency. Labor rates for 2003 were made that were obtained from the Bureau of Labor Statistics (labor rates include 140 percent overhead). The incremental costs included a one-time cost for development of the improved monitoring and recurring annual burden costs for incremental record keeping, reporting, and certification activities.

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$620 per ton PM reduced (2003\$).

Comments:

Status:	Last Reviewed: 2004
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AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM2.5 Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 2003.

BLS, 2003: Bureau of Labor Statistics, "Employer Costs for Employee Compensation – June 2003," Table 12, page 16, 2003.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Commercial Institutional Boilers - Solid Waste

Control Measure Name: CEM Upgrade and Increased Monitoring Frequency of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P4231

POD: 231

Application: This measure examines the impacts of improving the PM monitoring technique at units currently using an ESP, scrubber, or fabric filter. In this improved technique scenario, the monitoring technique is upgraded to a PM continuous emission monitor. This improved monitoring technique also results in an increase to the monitoring frequency because a PM CEMS can make a measurement every 7.5 minutes. The monitoring frequency increases from once per day to eight times per hour.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (see References) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

103012** Commercial/Institutional, Solid Waste

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 7.7% for both PM10 and PM2.5

Equipment Life: Unknown

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The total capital and annual operating costs for implementing an improved monitoring technique are calculated based on data from the EPA CEMS Cost Model and the PM CEMS Knowledge document. Labor rates in the EPA CEMS Cost Model are scaled to reflect 2003 labor rates (including 140 percent overhead) provided by the Bureau of Labor Statistics.

The cost effectiveness at a percent excess emission rate of 0.46 percent is \$5,200 per ton of PM2.5. This is based on a \$34 million capital investment cost, and a \$14 million total annualized cost when applied to 128 facilities.

Note: All costs are in 2003 dollars.

AT-A-GLANCE TABLE FOR POINT SOURCES

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$5,200 per ton PM reduced (2003\$).

Comments:

Status:

Last Reviewed: 2004

Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM_{2.5} Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 8, 2003.

EPA CEMS Cost Model, Version 3.0, U.S. Environmental Protection Agency.

EPA, 2000: U.S. Environmental Protection Agency, "Current Knowledge of Particulate Matter (PM) Continuous Emissions Monitoring," Chapter 9, PM CEMS Cost, September 8, 2000.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Commercial Institutional Boilers - Wood

Control Measure Name: Increased Monitoring Frequency (IMF) of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P3206

POD: 206

Application: This measure is to conduct improved monitoring for PM_{2.5} emissions at stationary sources. Improved monitoring in this case means increasing the monitoring frequency of electrostatic precipitators, scrubbers, and fabric filters from once per day to four times per hour, with no change in monitoring technique.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (Barr and Schaffner) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

103009** Commercial/Institutional, Wood/Bark Waste

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 6.5% for both PM₁₀ and PM_{2.5}

Equipment Life: Not applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs included the incremental record keeping and reporting associated with the increased monitoring frequency. Labor rates for 2003 were made that were obtained from the Bureau of Labor Statistics (labor rates include 140 percent overhead). The incremental costs included a one-time cost for development of the improved monitoring and recurring annual burden costs for incremental record keeping, reporting, and certification activities.

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$620 per ton PM reduced (2003\$).

Comments:

Status:

Last Reviewed: 2004

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM2.5 Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 2003.

BLS, 2003: Bureau of Labor Statistics, "Employer Costs for Employee Compensation – June 2003," Table 12, page 16, 2003.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Commercial Institutional Boilers - Wood

Control Measure Name: CEM Upgrade and Increased Monitoring Frequency of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P4206

POD: 206

Application: This measure examines the impacts of improving the PM monitoring technique at units currently using an ESP, scrubber, or fabric filter. In this improved technique scenario, the monitoring technique is upgraded to a PM continuous emission monitor. This improved monitoring technique also results in an increase to the monitoring frequency because a PM CEMS can make a measurement every 7.5 minutes. The monitoring frequency increases from once per day to eight times per hour.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (see References) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

103009** Commercial/Institutional, Wood/Bark Waste

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 7.7% for both PM10 and PM2.5

Equipment Life: Unknown

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The total capital and annual operating costs for implementing an improved monitoring technique are calculated based on data from the EPA CEMS Cost Model and the PM CEMS Knowledge document. Labor rates in the EPA CEMS Cost Model are scaled to reflect 2003 labor rates (including 140 percent overhead) provided by the Bureau of Labor Statistics.

The cost effectiveness at a percent excess emission rate of 0.46 percent is \$5,200 per ton of PM2.5. This is based on a \$34 million capital investment cost, and a \$14 million total annualized cost when applied to 128 facilities.

Note: All costs are in 2003 dollars.

AT-A-GLANCE TABLE FOR POINT SOURCES

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$5,200 per ton PM reduced (2003\$).

Comments:

Status:

Last Reviewed: 2004

Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM_{2.5} Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 8, 2003.

EPA CEMS Cost Model, Version 3.0, U.S. Environmental Protection Agency.

EPA, 2000: U.S. Environmental Protection Agency, "Current Knowledge of Particulate Matter (PM) Continuous Emissions Monitoring," Chapter 9, PM CEMS Cost, September 8, 2000.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Commercial Institutional Boilers - Wood/Bark

Control Measure Name: Fabric Filter (Pulse Jet Type)

Rule Name: Not Applicable

Pechan Measure Code: P2061

POD: 206

Application: This control is the addition of a pulse-jet cleaned fabric filter to reduce PM emissions from waste streams. In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Particulate-laden gas flows into the filter bag from the outside to the inside. The particles collected on the outside drop into a hopper below the fabric filter. During pulse-jet cleaning, a short burst of high pressure air is injected into the bags, dislodging the dust cake.

This control applies to commercial institutional operations with wood-fired boilers.

Affected SCC:

10300901 Wood/Bark Waste, Bark-fired Boiler

10300902 Wood/Bark Waste, Wood/Bark-fired Boiler

10300903 Commercial/Institutional, Wood/Bark Waste, Wood-fired Boiler

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 99% from uncontrolled for both PM10 and PM2.5

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs for pulse-jet cleaned systems are generated using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan,2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 2000).. Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual,

AT-A-GLANCE TABLE FOR POINT SOURCES

with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$6 to \$26 per scfm
Typical value is \$13 per scfm

O&M Costs:

Range from \$5 to \$24 per scfm
Typical value is \$11 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). O&M costs were calculated for three model plants with flow rates of 25, 75 and 150 thousand acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust loading of 4.0 grains per cubic feet. The operating time was assumed to be 8760 hours per year. An average bag cost was estimated using the costs for standard bag types. Capital recovery for the periodic replacement of bags was included in the O&M cost of the bags using a bag life of 2 years (EPA, 1998a). The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.0671	\$/kW-hr
Compressed air	0.25	\$/1000 scf
Dust disposal	25	\$/ton disposed

Note: All costs are in 1998 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$42 to \$266 per ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$117 per ton PM10 reduced. (1998\$)

Comments:

Status: Demonstrated	Last Reviewed: 2001
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Additional Information:

The cost estimates assume a conventional design under typical operating conditions and do not include auxiliary equipment such as fans and ductwork. The costs for pulse-jet cleaned systems are generated using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a).

Costs are primarily based on volumetric flow rate and the amount of PM in the waste stream. In general, a small unit controlling a low pollutant levels will not be as cost effective as a large unit controlling a high pollutant levels. (EPA, 2000)

Pollutants requiring a high level of control or the fabric filters to be constructed of special materials will increase the costs of the system (EPA, 1998a). The additional costs for controlling complex waste streams are not included in the estimates. For these systems, the capital cost could increase by as much as 75% and the operational and maintenance (O&M) cost could increase by as much as 20% (EPA, 2000).

AT-A-GLANCE TABLE FOR POINT SOURCES

In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Fabric filters may be in the form of sheets, cartridges, or bags, with many individual filter units together in a group. Bags are the most common type of filter. The dust cake that forms on the filter from the collected PM can significantly increase collection efficiency. (EPA, 2000)

Pulse-jet cleaning of fabric filters is a relatively new type of fabric filter, as they have only been used for the past 30 years. This cleaning mechanism has grown in popularity because it can treat high dust loadings, operate at constant pressure drop, and occupy less space than other types of fabric filters (EPA, 2000). Particulate-laden gas flows into the bag. The gas flows from the outside to the inside of the bags, and then out the gas exhaust. The particles collected on the outside drop into a hopper below the fabric filter (EPA, 1998b).

During pulse-jet cleaning, a short burst of high pressure air is injected into the bags (EPA, 1998b). The pulse is blown through a venturi nozzle at the top of the bags and establishes a shock wave that continues onto the bottom of the bag. The wave flexes the fabric dislodging the dust cake.

There are several unique attributes of pulse-jet cleaning. The cleaning pulse is very brief allowing the flow of dusty gas to continue during cleaning. The bags not being cleaned continue to filter, taking on extra duty from the bags being cleaned (EPA, 2000). Pulse-jet cleaning is more intense and occurs with greater frequency than the other fabric filter cleaning methods. The cleaning dislodges nearly all of the dust cake each time the bag is pulsed. Pulse-jet filters, as a result, do not rely on a dust cake to provide filtration. Felted (non-woven) fabrics are used in these types of filters because they do not require a dust cake. Also it has been found that woven fabrics used with pulse-jet cleaning leak dust after they are cleaned (EPA, 1998b).

Since bags cleaned by the pulse-jet method do not need to be isolated for cleaning, pulsejet cleaned fabric filters do not need extra compartments to maintain adequate filtration during cleaning. Also, because of the intense and frequent nature of the cleaning, they can treat higher gas flow rates with higher dust loadings. Consequently, fabric filters cleaned by the pulse-jet method can be smaller than other filters in the treatment of the same amount of gas and dust, making higher gas-to-cloth ratios achievable (EPA, 1998b).

Fabric filters are useful for collecting particles with resistivities either too low or too high for collection with electrostatic precipitators. Fabric filters are useful in controlling particulate matter less than or equal to 10 micrometers (μm) in diameter (PM₁₀) and particulate matter less than or equal to 2.5 μm in diameter (PM_{2.5}). Fabric filters may be good candidates for collecting fly ash from low-sulfur coals or containing high unburned carbon levels and are relatively difficult to collect with electrostatic precipitators. (EPA, 2000)

References:

EPA, 1998a: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, Chapter 5, EPA 453/B-96-001, Research Triangle Park, NC. December 1998.

EPA, 1998b: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

EPA, 2000: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Fabric Filter - Pulse-Jet Cleaned Type," April 2000.

AT-A-GLANCE TABLE FOR POINT SOURCES

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Commercial Institutional Boilers - Wood/Bark

Control Measure Name: Dry ESP-Wire Plate Type

Rule Name: Not Applicable

Pechan Measure Code: P2062

POD: 206

Application: This control is the use of dry electrostatic precipitators (ESP) to reduce PM emissions. An ESP uses electrical forces to move particles in an exhaust stream onto collector plates. Electrodes in the center of the flow are maintained at high voltage and generate an electrical field forcing particles to the collector walls. In dry ESPs, the collectors are knocked by various mechanical means to dislodge the particulate, which slides downward into a hopper.

This control applies to point sources with wood-fired boilers.

Affected SCC:

10300901 Wood/Bark Waste, Bark-fired Boiler

10300902 Wood/Bark Waste, Wood/Bark-fired Boiler

10300903 Commercial/Institutional, Wood/Bark Waste, Wood-fired Boiler

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: PM10 control efficiency is 98% from uncontrolled; PM2.5 control efficiency is 95% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs for ESPs of conventional design under typical operating conditions are developed using EPA cost estimating spreadsheets (EPA, 1996). When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan, 2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 1999). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of

AT-A-GLANCE TABLE FOR POINT SOURCES

equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$15 to \$50 per scfm
Typical value is \$27 per scfm

O&M Costs:

Range from \$4 to \$40 per scfm
Typical value is \$16 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for ESP (EPA, 1996). O&M costs were calculated for three model plants with flow rates of 200 and 500 thousand acfm and 1 million acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust loading of 6.0 grains per cubic feet. The operating time was assumed to be 8640 hours per year. The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.067	\$/kW-hr
Dust disposal	25	\$/ton disposed

Note: All costs are in 1995 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$40 to \$250 per ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$110 per ton PM10 reduced. (1995\$)

Comments:

Status: Demonstrated	Last Reviewed: 2001
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Additional Information:

In the wire-plate ESP, the gas flows around vertical, metal plates. The electrodes are long, weighted wires hanging between the plates. The voltage applied to the electrodes causes the gas between the electrodes to break down, known as a "corona." The electrodes are most often given a negative polarity because a negative corona supports a higher voltage than a positive corona.

Certain types of losses affect control efficiency. The dislodging of the accumulated layer also projects some of the particles back into the gas stream. These particles are processed in later sections of the ESP, but the particles from the last section have no chance to be recaptured. Due to the space needed at the top of the ESP for nonelectrified components, part of the stream may flow around the charged zones. This is called "sneakage" and places an upper limit on the collection efficiency of the ESP. Anti-sneakage baffles are used to force the sneakage flow to mix with the main gas stream for collection in later sections (EPA, 1998).

Another factor in the performance of ESPs is the resistivity of the collected material. All the ion current must pass through the collected layer to reach the ground plates. This creates an electric

AT-A-GLANCE TABLE FOR POINT SOURCES

field in the layer, and it can become large enough to cause electrical breakdown. When this occurs, new ions of the wrong polarity are injected into the wire-plate gap reducing the charge on the particles, which may cause sparking. This condition is called "back corona." When this happens the collection ability of the unit is reduced. At low resistivities the particles are held on the plates so loosely that reentrainment levels are much higher. Hence, care must be taken in measuring or estimating resistivity because it is strongly affected by such variables as temperature, moisture, gas composition, particle composition, and surface characteristics (EPA, 1999).

Dusts with high resistivities are also not well-suited for collection in dry ESPs. These particles are not easily charged nor easily collected. High-resistivity particles form ash layers with very high voltage gradients on the collecting electrodes lead to back corona, reducing the charge on particles and lowering collection efficiency. Fly ash from the combustion of low-sulfur coal typically has a high resistivity, and thus is difficult to collect using dry ESPs (EPA, 1999).

References:

EPA, 1996: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, EPA 453/B-96-001, Research Triangle Park, NC. February 1996.

EPA, 1998: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

EPA, 1999: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Dry Electrostatic Precipitator (ESP) - Wire-Plate Type," May 1999.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Commercial Institutional Boilers - Wood/Bark

Control Measure Name: Fabric Filter (Reverse-Air Cleaned Type)

Rule Name: Not Applicable

Pechan Measure Code: P2063

POD: 206

Application: This control is the use of a reverse-air cleaned fabric filter to reduce PM emissions from waste streams. In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Reverse-air cleaning is performed by forcing clean air through the filters in the opposite direction of the dusty gas flow. The change in direction of the gas flow causes the bag to flex and crack the filter cake allowing for internal cake collection.

This control applies to commercial institutional operations with wood-fired boilers.

Affected SCC:

10300901 Wood/Bark Waste, Bark-fired Boiler

10300902 Wood/Bark Waste, Wood/Bark-fired Boiler

10300903 Commercial/Institutional, Wood/Bark Waste, Wood-fired Boiler

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 99% from uncontrolled for both PM10 and PM2.5

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs for reverse-air cleaned systems are generated using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan,2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 2000). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual,

AT-A-GLANCE TABLE FOR POINT SOURCES

with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$9 to \$84 per scfm
Typical value is \$34 per scfm

O&M Costs:

Range from \$6 to \$27 per scfm
Typical value is \$13 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). O&M costs were calculated for three model plants with flow rates of 25, 75 and 150 thousand acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust loading of 4.0 grains per cubic feet. The operating time was assumed to be 8760 hours per year. An average bag cost was estimated using the costs for standard bag types. Capital recovery for the periodic replacement of bags was included in the O&M cost of the bags using a bag life of 2 years (EPA, 1998a). The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.0671	\$/kW-hr
Compressed air	0.25	\$/1000 scf
Dust disposal	25	\$/ton disposed

Note: All costs are in 1998 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$53 to \$337 per ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$148 per ton PM10 reduced. (1998\$)

Comments:

Status: Demonstrated	Last Reviewed: 2001
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Additional Information:

The cost estimates assume a conventional design under typical operating conditions. The costs do not include any auxiliary equipment (EPA, 2000).

The capital cost for the reverse-jet cleaned fabric baghouse is based on information provided by a manufacturer (EPA, 2000). The capital cost includes only the purchased equipment cost.

Costs are primarily based on volumetric flow rate and the amount of PM in the waste stream. In general, a small unit controlling a low pollutant levels will not be as cost effective as a large unit controlling a high pollutant levels. (EPA, 2000)

Pollutants requiring a high level of control or the fabric filters to be constructed of special materials will increase the costs of the system (EPA, 1998a). The additional costs for controlling complex streams are not reflected in the estimates. For these systems, the capital cost could increase by as

AT-A-GLANCE TABLE FOR POINT SOURCES

much as 40% and the O&M cost could increase by as much as 5%. (EPA, 2000)

In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Fabric filters may be in the form of sheets, cartridges, or bags, with many individual filter units together in a group. Bags are the most common type of filter. The dust cake that forms on the filter from the collected PM can significantly increase collection efficiency. (EPA, 2000)

Reverse-air cleaning is a popular filter cleaning method as it has been used extensively and improved over the years. It is a gentler but sometimes less effective clearing mechanism than mechanical shaking. Reverse-air cleaning is performed by forcing clean air through the filters in the opposite direction of the dusty gas flow. The change in direction of the gas flow causes the bag to flex and crack the filter cake allowing for internal cake collection (EPA, 2000).

The most common design is to have separate compartments within the fabric filter so that each can be isolated and cleaned separately while the others continue to treat the dusty gas. There are several methods of reversing the flow through the filters. One method of providing the reverse flow is by the use of a fan or cleaned gas from other compartments. Reverse-air cleaning only used alone in cases where the dust releases easily from the fabric. In many instances, reverse-air is used along with shaking, pulsing or sonic horns (EPA, 1998b).

Fabric filters are useful for collecting particles with resistivities either too low or too high for collection with electrostatic precipitators. Fabric filters are useful in controlling particulate matter less than or equal to 10 micrometers (μm) in diameter (PM₁₀) and particulate matter less than or equal to 2.5 μm in diameter (PM_{2.5}). Fabric filters may be good candidates for collecting fly ash from low-sulfur coals or containing high unburned carbon levels and are relatively difficult to collect with electrostatic precipitators. (EPA, 2000)

References:

EPA, 1998b: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

EPA, 1998a: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, Chapter 5, EPA 453/B-96-001, Research Triangle Park, NC. December 1998.

EPA, 2000: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Fabric Filter - Reverse-Air Cleaned Type," April 2000.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Construction Activities

Control Measure Name: Dust Control Plan

Rule Name: Dust Control Plan

Pechan Measure Code: Pcnst

POD: N/A

Application: The dust control plan includes chemical suppression and water treatment of disturbed soil at construction sites.

This control is useful in the reduction of PM from construction areas, including heavy construction sites and road construction operations.

Affected SCC:

2311010000 General Building Construction, Total

2311020000 Heavy Construction, Total

2311030000 Road Construction, Total

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: PM10 control efficiency is 63% from uncontrolled; PM2.5 control efficiency is 37% from uncontrolled.

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The annual cost for the dust control plan (\$4,900 per acre) can be calculated as the sum of the annual costs for each control technique:

Site watering = \$1,395 per acre (\$3,720 per acre x 1 acre x 37.5 percent);

Chemical stabilization = \$3,506 per acre (\$9,350 per acre x 1 acre x 37.5 percent).

Annual emission reductions for the dust control plan can be calculated by applying the 75 percent penetration factor and overall 62.5 percent control efficiency to annual emissions. For one acre of construction activity, a 1.36 tpy reduction in PM-10 emissions is estimated for the dust control plan. Based on this information, the cost effectiveness of the dust control plan is estimated to be \$3,600 per ton of PM-10 reduced (Pechan, 1997).

Note: All costs are in 1990 dollars.

Cost Effectiveness: The cost effectiveness is \$3,600 per ton PM10 reduced (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 1997

AT-A-GLANCE TABLE FOR AREA SOURCES

Additional Information:

The most complete information available pertaining to construction PM emissions control is for site watering. Site watering is an attractive option because many construction jobs already have necessary equipment and facilities and need only more personnel for this task (EPA, 1974). The length of PM emission reduction from site watering is brief, requiring more than one application a day. Chemical suppressants provide a higher level of control which is longer-lasting than site watering. The higher cost of suppressants versus watering generally precludes their use in construction areas that undergo substantial improvements (e.g., earthmoving).

Chemical stabilization efficiency is dependent upon application rates. The EPA recommends that at least dilute reapplications be employed every month (EPA, 1994).

References:

EPA, 1974: U.S. Environmental Protection Agency, "Investigation of Fugitive Dust, Volume I- Sources, Emissions, and Control," EPA-450/3-74-036a. June 1974.

EPA, 1994: U.S. Environmental Protection Agency, Office of Policy, Planning, and Evaluation, National PM Study: "OPPE Particulate Programs Implementation Evaluation System," Washington, DC. September 1994.

Pechan, 1997: E.H. Pechan & Associates, "Additional Control Measure Evaluation for the Integrated Implementation of the Ozone and Particulate Matter National Ambient Air Quality Standards, and Regional Haze Program," prepared for U.S. Environmental Protection Agency, July 1997.

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Conveyorized Charbroilers

Control Measure Name: Catalytic Oxidizer

Rule Name: Not Applicable

Pechan Measure Code: Pcharb

POD: N/A

Application: Catalytic Oxidizer control device burns or oxidizes smoke and gases from the cooking process to carbon dioxide and water, using an infrastructure coated with a noble metal alloy.

Affected SCC:

2302002000 Food and Kindred Products: SIC 20, Commercial Charbroiling, Total

2302002100 Food and Kindred Products: SIC 20, Commercial Charbroiling

2302002200 Food and Kindred Products: SIC 20, Commercial Charbroiling

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*				√				

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 83% from uncontrolled for PM & VOC

Equipment Life: 10 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Control costs were estimated by assuming that replacement catalyst is bought when the original system is purchased.

The Cost per ton calculation:

Baseline PM Emissions per restaurant = 0.61 tons / yr

Capital Recovery Factor (CRF) (10 years @ 8%) = 0.149

\$ / ton = [0.149(\$5,657.5 + \$3,700)] + \$107.5 / [(0.83 reduction) (0.61 PM)]

= \$2,966 / year

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$2966 per ton PM reduced (2001\$).

Comments:

Status: Demonstrated

Last Reviewed: 2005

Additional Information:

References:

Ventura County, 2004: Ventura County, "Final Staff Report: Proposed New Rule 74.25, Restaurant Cooking Operations Proposed Revisions to Rule 23, Exemptions From Permit", August 31, 2004

CE-ERT, 2002: CE-CERT, UC-Riverside: "Assessment of Emissions from a Chain-Driven Charbroilers using a Catalytic Control device." Final Report for Engelhard Corp., September 13, 2002

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Electric Generation - Coke

Control Measure Name: Increased Monitoring Frequency (IMF) of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P3232

POD: 232

Application: This measure is to conduct improved monitoring for PM_{2.5} emissions at stationary sources. Improved monitoring in this case means increasing the monitoring frequency of electrostatic precipitators, scrubbers, and fabric filters from once per day to four times per hour, with no change in monitoring technique.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (Barr and Schaffner) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

101008** Electric Generation, Coke

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 6.5% for both PM₁₀ and PM_{2.5}

Equipment Life: Not applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs included the incremental record keeping and reporting associated with the increased monitoring frequency. Labor rates for 2003 were made that were obtained from the Bureau of Labor Statistics (labor rates include 140 percent overhead). The incremental costs included a one-time cost for development of the improved monitoring and recurring annual burden costs for incremental record keeping, reporting, and certification activities.

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$620 per ton PM reduced (2003\$).

Comments:

Status:

Last Reviewed: 2004

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM2.5 Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 2003.

BLS, 2003: Bureau of Labor Statistics, "Employer Costs for Employee Compensation – June 2003," Table 12, page 16, 2003.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Electric Generation - Coke

Control Measure Name: CEM Upgrade and Increased Monitoring Frequency of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P4232

POD: 232

Application: This measure examines the impacts of improving the PM monitoring technique at units currently using an ESP, scrubber, or fabric filter. In this improved technique scenario, the monitoring technique is upgraded to a PM continuous emission monitor. This improved monitoring technique also results in an increase to the monitoring frequency because a PM CEMS can make a measurement every 7.5 minutes. The monitoring frequency increases from once per day to eight times per hour.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (see References) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

101008** Electric Generation, Coke

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 7.7% for both PM10 and PM2.5

Equipment Life: Unknown

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The total capital and annual operating costs for implementing an improved monitoring technique are calculated based on data from the EPA CEMS Cost Model and the PM CEMS Knowledge document. Labor rates in the EPA CEMS Cost Model are scaled to reflect 2003 labor rates (including 140 percent overhead) provided by the Bureau of Labor Statistics.

The cost effectiveness at a percent excess emission rate of 0.46 percent is \$5,200 per ton of PM2.5. This is based on a \$34 million capital investment cost, and a \$14 million total annualized cost when applied to 128 facilities.

Note: All costs are in 2003 dollars.

AT-A-GLANCE TABLE FOR POINT SOURCES

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$5,200 per ton PM reduced (2003\$).

Comments:

Status:

Last Reviewed: 2004

Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM_{2.5} Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 8, 2003.

EPA CEMS Cost Model, Version 3.0, U.S. Environmental Protection Agency.

EPA, 2000: U.S. Environmental Protection Agency, "Current Knowledge of Particulate Matter (PM) Continuous Emissions Monitoring," Chapter 9, PM CEMS Cost, September 8, 2000.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Electric Generation - Bagasse

Control Measure Name: Increased Monitoring Frequency (IMF) of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P3233

POD: 233

Application: This measure is to conduct improved monitoring for PM_{2.5} emissions at stationary sources. Improved monitoring in this case means increasing the monitoring frequency of electrostatic precipitators, scrubbers, and fabric filters from once per day to four times per hour, with no change in monitoring technique.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (Barr and Schaffner) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

101011** Electric Generation, Bagasse

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 6.5% for both PM₁₀ and PM_{2.5}

Equipment Life: Not applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs included the incremental record keeping and reporting associated with the increased monitoring frequency. Labor rates for 2003 were made that were obtained from the Bureau of Labor Statistics (labor rates include 140 percent overhead). The incremental costs included a one-time cost for development of the improved monitoring and recurring annual burden costs for incremental record keeping, reporting, and certification activities.

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$620 per ton PM reduced (2003\$).

Comments:

Status:	Last Reviewed: 2004
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AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM_{2.5} Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 2003.

BLS, 2003: Bureau of Labor Statistics, "Employer Costs for Employee Compensation – June 2003," Table 12, page 16, 2003.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Electric Generation - Bagasse

Control Measure Name: CEM Upgrade and Increased Monitoring Frequency of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P4233

POD: 233

Application: This measure examines the impacts of improving the PM monitoring technique at units currently using an ESP, scrubber, or fabric filter. In this improved technique scenario, the monitoring technique is upgraded to a PM continuous emission monitor. This improved monitoring technique also results in an increase to the monitoring frequency because a PM CEMS can make a measurement every 7.5 minutes. The monitoring frequency increases from once per day to eight times per hour.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (see References) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

101011** Electric Generation, Bagasse

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 7.7% for both PM10 and PM2.5

Equipment Life: Unknown

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The total capital and annual operating costs for implementing an improved monitoring technique are calculated based on data from the EPA CEMS Cost Model and the PM CEMS Knowledge document. Labor rates in the EPA CEMS Cost Model are scaled to reflect 2003 labor rates (including 140 percent overhead) provided by the Bureau of Labor Statistics.

The cost effectiveness at a percent excess emission rate of 0.46 percent is \$5,200 per ton of PM2.5. This is based on a \$34 million capital investment cost, and a \$14 million total annualized cost when applied to 128 facilities.

Note: All costs are in 2003 dollars.

AT-A-GLANCE TABLE FOR POINT SOURCES

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$5,200 per ton PM reduced (2003\$).

Comments:

Status:

Last Reviewed: 2004

Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM_{2.5} Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 8, 2003.

EPA CEMS Cost Model, Version 3.0, U.S. Environmental Protection Agency.

EPA, 2000: U.S. Environmental Protection Agency, "Current Knowledge of Particulate Matter (PM) Continuous Emissions Monitoring," Chapter 9, PM CEMS Cost, September 8, 2000.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Electric Generation - Coal

Control Measure Name: Increased Monitoring Frequency (IMF) of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P3226

POD: 226

Application: This measure is to conduct improved monitoring for PM_{2.5} emissions at stationary sources. Improved monitoring in this case means increasing the monitoring frequency of electrostatic precipitators, scrubbers, and fabric filters from once per day to four times per hour, with no change in monitoring technique.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (Barr and Schaffner) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

101001** Electric Generation, Anthracite Coal

101003** Electric Generation, Lignite

101002** Electric Generation, Bituminous/Subbituminous Coal

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 6.5% for both PM₁₀ and PM_{2.5}

Equipment Life: Not applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs included the incremental record keeping and reporting associated with the increased monitoring frequency. Labor rates for 2003 were made that were obtained from the Bureau of Labor Statistics (labor rates include 140 percent overhead). The incremental costs included a one-time cost for development of the improved monitoring and recurring annual burden costs for incremental record keeping, reporting, and certification activities.

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$620 per ton PM reduced (2003\$).

Comments:

Status:

Last Reviewed: 2004

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM2.5 Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 2003.

BLS, 2003: Bureau of Labor Statistics, "Employer Costs for Employee Compensation – June 2003," Table 12, page 16, 2003.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Electric Generation - Coal

Control Measure Name: CEM Upgrade and Increased Monitoring Frequency of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P4226

POD: 226

Application: This measure examines the impacts of improving the PM monitoring technique at units currently using an ESP, scrubber, or fabric filter. In this improved technique scenario, the monitoring technique is upgraded to a PM continuous emission monitor. This improved monitoring technique also results in an increase to the monitoring frequency because a PM CEMS can make a measurement every 7.5 minutes. The monitoring frequency increases from once per day to eight times per hour.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (see References) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

101001** Electric Generation, Anthracite Coal

101003** Electric Generation, Lignite

101002** Electric Generation, Bituminous/Subbituminous Coal

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 7.7% for both PM10 and PM2.5

Equipment Life: Unknown

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The total capital and annual operating costs for implementing an improved monitoring technique are calculated based on data from the EPA CEMS Cost Model and the PM CEMS Knowledge document. Labor rates in the EPA CEMS Cost Model are scaled to reflect 2003 labor rates (including 140 percent overhead) provided by the Bureau of Labor Statistics.

The cost effectiveness at a percent excess emission rate of 0.46 percent is \$5,200 per ton of PM2.5. This is based on a \$34 million capital investment cost, and a \$14 million total annualized cost when applied to 128 facilities.

AT-A-GLANCE TABLE FOR POINT SOURCES

Note: All costs are in 2003 dollars.

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$5,200 per ton PM reduced (2003\$).

Comments:

Status:

Last Reviewed: 2004

Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM_{2.5} Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 8, 2003.

EPA CEMS Cost Model, Version 3.0, U.S. Environmental Protection Agency.

EPA, 2000: U.S. Environmental Protection Agency, "Current Knowledge of Particulate Matter (PM) Continuous Emissions Monitoring," Chapter 9, PM CEMS Cost, September 8, 2000.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Electric Generation - Liquid Waste

Control Measure Name: Increased Monitoring Frequency (IMF) of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P3235

POD: 235

Application: This measure is to conduct improved monitoring for PM_{2.5} emissions at stationary sources. Improved monitoring in this case means increasing the monitoring frequency of electrostatic precipitators, scrubbers, and fabric filters from once per day to four times per hour, with no change in monitoring technique.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (Barr and Schaffner) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

101013** Electric Generation, Liquid Waste

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 6.5% for both PM₁₀ and PM_{2.5}

Equipment Life: Not applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs included the incremental record keeping and reporting associated with the increased monitoring frequency. Labor rates for 2003 were made that were obtained from the Bureau of Labor Statistics (labor rates include 140 percent overhead). The incremental costs included a one-time cost for development of the improved monitoring and recurring annual burden costs for incremental record keeping, reporting, and certification activities.

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$620 per ton PM reduced (2003\$).

Comments:

Status:

Last Reviewed: 2004

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM2.5 Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 2003.

BLS, 2003: Bureau of Labor Statistics, "Employer Costs for Employee Compensation – June 2003," Table 12, page 16, 2003.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Electric Generation - Liquid Waste

Control Measure Name: CEM Upgrade and Increased Monitoring Frequency of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P4235

POD: 235

Application: This measure examines the impacts of improving the PM monitoring technique at units currently using an ESP, scrubber, or fabric filter. In this improved technique scenario, the monitoring technique is upgraded to a PM continuous emission monitor. This improved monitoring technique also results in an increase to the monitoring frequency because a PM CEMS can make a measurement every 7.5 minutes. The monitoring frequency increases from once per day to eight times per hour.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (see References) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

101013** Electric Generation, Liquid Waste

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 7.7% for both PM10 and PM2.5

Equipment Life: Unknown

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The total capital and annual operating costs for implementing an improved monitoring technique are calculated based on data from the EPA CEMS Cost Model and the PM CEMS Knowledge document. Labor rates in the EPA CEMS Cost Model are scaled to reflect 2003 labor rates (including 140 percent overhead) provided by the Bureau of Labor Statistics.

The cost effectiveness at a percent excess emission rate of 0.46 percent is \$5,200 per ton of PM2.5. This is based on a \$34 million capital investment cost, and a \$14 million total annualized cost when applied to 128 facilities.

Note: All costs are in 2003 dollars.

AT-A-GLANCE TABLE FOR POINT SOURCES

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$5,200 per ton PM reduced (2003\$).

Comments:

Status:

Last Reviewed: 2004

Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM_{2.5} Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 8, 2003.

EPA CEMS Cost Model, Version 3.0, U.S. Environmental Protection Agency.

EPA, 2000: U.S. Environmental Protection Agency, "Current Knowledge of Particulate Matter (PM) Continuous Emissions Monitoring," Chapter 9, PM CEMS Cost, September 8, 2000.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Electric Generation - LPG

Control Measure Name: Increased Monitoring Frequency (IMF) of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P3234

POD: 234

Application: This measure is to conduct improved monitoring for PM_{2.5} emissions at stationary sources. Improved monitoring in this case means increasing the monitoring frequency of electrostatic precipitators, scrubbers, and fabric filters from once per day to four times per hour, with no change in monitoring technique.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (Barr and Schaffner) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

101010** Electric Generation, Liquified Petroleum Gas (LPG)

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 6.5% for both PM₁₀ and PM_{2.5}

Equipment Life: Not applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs included the incremental record keeping and reporting associated with the increased monitoring frequency. Labor rates for 2003 were made that were obtained from the Bureau of Labor Statistics (labor rates include 140 percent overhead). The incremental costs included a one-time cost for development of the improved monitoring and recurring annual burden costs for incremental record keeping, reporting, and certification activities.

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$620 per ton PM reduced (2003\$).

Comments:

Status:	Last Reviewed: 2004
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AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM2.5 Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 2003.

BLS, 2003: Bureau of Labor Statistics, "Employer Costs for Employee Compensation – June 2003," Table 12, page 16, 2003.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Electric Generation - LPG

Control Measure Name: CEM Upgrade and Increased Monitoring Frequency of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P4234

POD: 234

Application: This measure examines the impacts of improving the PM monitoring technique at units currently using an ESP, scrubber, or fabric filter. In this improved technique scenario, the monitoring technique is upgraded to a PM continuous emission monitor. This improved monitoring technique also results in an increase to the monitoring frequency because a PM CEMS can make a measurement every 7.5 minutes. The monitoring frequency increases from once per day to eight times per hour.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (see References) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

101010** Electric Generation, Liquified Petroleum Gas (LPG)

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 7.7% for both PM10 and PM2.5

Equipment Life: Unknown

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The total capital and annual operating costs for implementing an improved monitoring technique are calculated based on data from the EPA CEMS Cost Model and the PM CEMS Knowledge document. Labor rates in the EPA CEMS Cost Model are scaled to reflect 2003 labor rates (including 140 percent overhead) provided by the Bureau of Labor Statistics.

The cost effectiveness at a percent excess emission rate of 0.46 percent is \$5,200 per ton of PM2.5. This is based on a \$34 million capital investment cost, and a \$14 million total annualized cost when applied to 128 facilities.

Note: All costs are in 2003 dollars.

AT-A-GLANCE TABLE FOR POINT SOURCES

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$5,200 per ton PM reduced (2003\$).

Comments:

Status:

Last Reviewed: 2004

Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM_{2.5} Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 8, 2003.

EPA CEMS Cost Model, Version 3.0, U.S. Environmental Protection Agency.

EPA, 2000: U.S. Environmental Protection Agency, "Current Knowledge of Particulate Matter (PM) Continuous Emissions Monitoring," Chapter 9, PM CEMS Cost, September 8, 2000.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Electric Generation - Natural Gas

Control Measure Name: Increased Monitoring Frequency (IMF) of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P3236

POD: 236

Application: This measure is to conduct improved monitoring for PM_{2.5} emissions at stationary sources. Improved monitoring in this case means increasing the monitoring frequency of electrostatic precipitators, scrubbers, and fabric filters from once per day to four times per hour, with no change in monitoring technique.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (Barr and Schaffner) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

101006** Electric Generation, Natural Gas

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 6.5% for both PM₁₀ and PM_{2.5}

Equipment Life: Not applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs included the incremental record keeping and reporting associated with the increased monitoring frequency. Labor rates for 2003 were made that were obtained from the Bureau of Labor Statistics (labor rates include 140 percent overhead). The incremental costs included a one-time cost for development of the improved monitoring and recurring annual burden costs for incremental record keeping, reporting, and certification activities.

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$620 per ton PM reduced (2003\$).

Comments:

Status:

Last Reviewed: 2004

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM2.5 Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 2003.

BLS, 2003: Bureau of Labor Statistics, "Employer Costs for Employee Compensation – June 2003," Table 12, page 16, 2003.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Electric Generation - Natural Gas

Control Measure Name: CEM Upgrade and Increased Monitoring Frequency of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P4236

POD: 236

Application: This measure examines the impacts of improving the PM monitoring technique at units currently using an ESP, scrubber, or fabric filter. In this improved technique scenario, the monitoring technique is upgraded to a PM continuous emission monitor. This improved monitoring technique also results in an increase to the monitoring frequency because a PM CEMS can make a measurement every 7.5 minutes. The monitoring frequency increases from once per day to eight times per hour.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (see References) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

101006** Electric Generation, Natural Gas

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 7.7% for both PM10 and PM2.5

Equipment Life: Unknown

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The total capital and annual operating costs for implementing an improved monitoring technique are calculated based on data from the EPA CEMS Cost Model and the PM CEMS Knowledge document. Labor rates in the EPA CEMS Cost Model are scaled to reflect 2003 labor rates (including 140 percent overhead) provided by the Bureau of Labor Statistics.

The cost effectiveness at a percent excess emission rate of 0.46 percent is \$5,200 per ton of PM2.5. This is based on a \$34 million capital investment cost, and a \$14 million total annualized cost when applied to 128 facilities.

Note: All costs are in 2003 dollars.

AT-A-GLANCE TABLE FOR POINT SOURCES

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$5,200 per ton PM reduced (2003\$).

Comments:

Status:

Last Reviewed: 2004

Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM_{2.5} Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 8, 2003.

EPA CEMS Cost Model, Version 3.0, U.S. Environmental Protection Agency.

EPA, 2000: U.S. Environmental Protection Agency, "Current Knowledge of Particulate Matter (PM) Continuous Emissions Monitoring," Chapter 9, PM CEMS Cost, September 8, 2000.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Electric Generation - Oil

Control Measure Name: Increased Monitoring Frequency (IMF) of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P3237

POD: 237

Application: This measure is to conduct improved monitoring for PM_{2.5} emissions at stationary sources. Improved monitoring in this case means increasing the monitoring frequency of electrostatic precipitators, scrubbers, and fabric filters from once per day to four times per hour, with no change in monitoring technique.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (Barr and Schaffner) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

101004** Electric Generation, Residual Oil

101005** Electric Generation, Distillate Oil

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 6.5% for both PM₁₀ and PM_{2.5}

Equipment Life: Not applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs included the incremental record keeping and reporting associated with the increased monitoring frequency. Labor rates for 2003 were made that were obtained from the Bureau of Labor Statistics (labor rates include 140 percent overhead). The incremental costs included a one-time cost for development of the improved monitoring and recurring annual burden costs for incremental record keeping, reporting, and certification activities.

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$620 per ton PM reduced (2003\$).

Comments:

Status:

Last Reviewed: 2004

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM2.5 Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 2003.

BLS, 2003: Bureau of Labor Statistics, "Employer Costs for Employee Compensation – June 2003," Table 12, page 16, 2003.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Electric Generation - Oil

Control Measure Name: CEM Upgrade and Increased Monitoring Frequency of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P4237

POD: 237

Application: This measure examines the impacts of improving the PM monitoring technique at units currently using an ESP, scrubber, or fabric filter. In this improved technique scenario, the monitoring technique is upgraded to a PM continuous emission monitor. This improved monitoring technique also results in an increase to the monitoring frequency because a PM CEMS can make a measurement every 7.5 minutes. The monitoring frequency increases from once per day to eight times per hour.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (see References) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

101004** Electric Generation, Residual Oil

101005** Electric Generation, Distillate Oil

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 7.7% for both PM10 and PM2.5

Equipment Life: Unknown

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The total capital and annual operating costs for implementing an improved monitoring technique are calculated based on data from the EPA CEMS Cost Model and the PM CEMS Knowledge document. Labor rates in the EPA CEMS Cost Model are scaled to reflect 2003 labor rates (including 140 percent overhead) provided by the Bureau of Labor Statistics.

The cost effectiveness at a percent excess emission rate of 0.46 percent is \$5,200 per ton of PM2.5. This is based on a \$34 million capital investment cost, and a \$14 million total annualized cost when applied to 128 facilities.

Note: All costs are in 2003 dollars.

AT-A-GLANCE TABLE FOR POINT SOURCES

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$5,200 per ton PM reduced (2003\$).

Comments:

Status:

Last Reviewed: 2004

Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM_{2.5} Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 8, 2003.

EPA CEMS Cost Model, Version 3.0, U.S. Environmental Protection Agency.

EPA, 2000: U.S. Environmental Protection Agency, "Current Knowledge of Particulate Matter (PM) Continuous Emissions Monitoring," Chapter 9, PM CEMS Cost, September 8, 2000.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Electric Generation - Solid Waste

Control Measure Name: Increased Monitoring Frequency (IMF) of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P3238

POD: 238

Application: This measure is to conduct improved monitoring for PM_{2.5} emissions at stationary sources. Improved monitoring in this case means increasing the monitoring frequency of electrostatic precipitators, scrubbers, and fabric filters from once per day to four times per hour, with no change in monitoring technique.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (Barr and Schaffner) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

101012** Electric Generation, Solid Waste

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 6.5% for both PM₁₀ and PM_{2.5}

Equipment Life: Not applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs included the incremental record keeping and reporting associated with the increased monitoring frequency. Labor rates for 2003 were made that were obtained from the Bureau of Labor Statistics (labor rates include 140 percent overhead). The incremental costs included a one-time cost for development of the improved monitoring and recurring annual burden costs for incremental record keeping, reporting, and certification activities.

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$620 per ton PM reduced (2003\$).

Comments:

Status:

Last Reviewed: 2004

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM2.5 Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 2003.

BLS, 2003: Bureau of Labor Statistics, "Employer Costs for Employee Compensation – June 2003," Table 12, page 16, 2003.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Electric Generation - Solid Waste

Control Measure Name: CEM Upgrade and Increased Monitoring Frequency of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P4238

POD: 238

Application: This measure examines the impacts of improving the PM monitoring technique at units currently using an ESP, scrubber, or fabric filter. In this improved technique scenario, the monitoring technique is upgraded to a PM continuous emission monitor. This improved monitoring technique also results in an increase to the monitoring frequency because a PM CEMS can make a measurement every 7.5 minutes. The monitoring frequency increases from once per day to eight times per hour.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (see References) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

101012** Electric Generation, Solid Waste

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 7.7% for both PM10 and PM2.5

Equipment Life: Unknown

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The total capital and annual operating costs for implementing an improved monitoring technique are calculated based on data from the EPA CEMS Cost Model and the PM CEMS Knowledge document. Labor rates in the EPA CEMS Cost Model are scaled to reflect 2003 labor rates (including 140 percent overhead) provided by the Bureau of Labor Statistics.

The cost effectiveness at a percent excess emission rate of 0.46 percent is \$5,200 per ton of PM2.5. This is based on a \$34 million capital investment cost, and a \$14 million total annualized cost when applied to 128 facilities.

Note: All costs are in 2003 dollars.

AT-A-GLANCE TABLE FOR POINT SOURCES

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$5,200 per ton PM reduced (2003\$).

Comments:

Status:

Last Reviewed: 2004

Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM_{2.5} Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 8, 2003.

EPA CEMS Cost Model, Version 3.0, U.S. Environmental Protection Agency.

EPA, 2000: U.S. Environmental Protection Agency, "Current Knowledge of Particulate Matter (PM) Continuous Emissions Monitoring," Chapter 9, PM CEMS Cost, September 8, 2000.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Electric Generation - Wood

Control Measure Name: Increased Monitoring Frequency (IMF) of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P3239

POD: 239

Application: This measure is to conduct improved monitoring for PM_{2.5} emissions at stationary sources. Improved monitoring in this case means increasing the monitoring frequency of electrostatic precipitators, scrubbers, and fabric filters from once per day to four times per hour, with no change in monitoring technique.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (Barr and Schaffner) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

101009** Electric Generation, Wood/Bark Waste

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 6.5% for both PM₁₀ and PM_{2.5}

Equipment Life: Not applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs included the incremental record keeping and reporting associated with the increased monitoring frequency. Labor rates for 2003 were made that were obtained from the Bureau of Labor Statistics (labor rates include 140 percent overhead). The incremental costs included a one-time cost for development of the improved monitoring and recurring annual burden costs for incremental record keeping, reporting, and certification activities.

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$620 per ton PM reduced (2003\$).

Comments:

Status:

Last Reviewed: 2004

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM2.5 Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 2003.

BLS, 2003: Bureau of Labor Statistics, "Employer Costs for Employee Compensation – June 2003," Table 12, page 16, 2003.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Electric Generation - Wood

Control Measure Name: CEM Upgrade and Increased Monitoring Frequency of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P4239

POD: 239

Application: This measure examines the impacts of improving the PM monitoring technique at units currently using an ESP, scrubber, or fabric filter. In this improved technique scenario, the monitoring technique is upgraded to a PM continuous emission monitor. This improved monitoring technique also results in an increase to the monitoring frequency because a PM CEMS can make a measurement every 7.5 minutes. The monitoring frequency increases from once per day to eight times per hour.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (see References) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

101009** Electric Generation, Wood/Bark Waste

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 7.7% for both PM10 and PM2.5

Equipment Life: Unknown

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The total capital and annual operating costs for implementing an improved monitoring technique are calculated based on data from the EPA CEMS Cost Model and the PM CEMS Knowledge document. Labor rates in the EPA CEMS Cost Model are scaled to reflect 2003 labor rates (including 140 percent overhead) provided by the Bureau of Labor Statistics.

The cost effectiveness at a percent excess emission rate of 0.46 percent is \$5,200 per ton of PM2.5. This is based on a \$34 million capital investment cost, and a \$14 million total annualized cost when applied to 128 facilities.

Note: All costs are in 2003 dollars.

AT-A-GLANCE TABLE FOR POINT SOURCES

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$5,200 per ton PM reduced (2003\$).

Comments:

Status:

Last Reviewed: 2004

Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM_{2.5} Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 8, 2003.

EPA CEMS Cost Model, Version 3.0, U.S. Environmental Protection Agency.

EPA, 2000: U.S. Environmental Protection Agency, "Current Knowledge of Particulate Matter (PM) Continuous Emissions Monitoring," Chapter 9, PM CEMS Cost, September 8, 2000.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Fabricated Metal Products - Abrasive Blasting

Control Measure Name: Paper/Nonwoven Filters - Cartridge Collector Type

Rule Name: Not Applicable

Pechan Measure Code: P2271

POD: 227

Application: This control is the use of paper or non-woven filters (cartridge collector type) to reduce PM emissions. The waste gas stream is passed through the fibrous filter media causing PM in the gas stream to be collected on the media by sieving and other mechanisms.

This control measure applies to abrasive blasting operations as a part of fabricated metal products processing and production.

Affected SCC:

30900201 Fabricated Metal Products, Abrasive Blasting of Metal Parts, General
30900202 Fabricated Metal Products, Abrasive Blasting of Metal Parts, Sand Abrasive
30900203 Fabricated Metal Products, Abrasive Blasting of Metal Parts, Slag Abrasive
30900205 Fabricated Metal Products, Abrasive Blasting of Metal Parts, Steel Grit Abrasive
30900207 Fabricated Metal Products, Abrasive Blasting of Metal Parts, Shotblast with Air
30900208 Abrasive Blasting of Metal Parts, Shotblast w/o Air
30900299 Fabricated Metal Products, Abrasive Blasting of Metal Parts, General

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 99% from uncontrolled for both PM10 and PM2.5

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs are generated using EPA's cost-estimating spreadsheets for fabric filters (EPA, 1998a). Costs are primarily driven by the waste stream volumetric flow rate and pollutant loading. When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan,2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 2000). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of

AT-A-GLANCE TABLE FOR POINT SOURCES

equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$7 to \$13 per scfm
Typical value is \$9 per scfm

O&M Costs:

Range from \$9 to \$25 per scfm
Typical value is \$14 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). O&M costs were calculated for three model plants with flow rates of 25, 75 and 150 thousand acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust loading of 4.0 grains per cubic feet. The operating time was assumed to be 8760 hours per year. An average cartridge cost was estimated using the costs for standard cartridge types. Capital recovery for the periodic replacement of cartridges was included in the O&M cost of the cartridges using a cartridge life of 2 years (EPA, 1998a). The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.0671	\$/kW-hr
Compressed air	0.25	\$/1000 scf
Dust disposal	25	\$/ton disposed

Note: All costs are in 1998 dollars.

Cost Effectiveness: When stack flow is available, the cost effectiveness varies from \$85 to \$256 per ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$142 per ton PM10 reduced. (1998\$)

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

The cost estimates assume a conventional design under typical operating conditions. Auxiliary equipment, such as fans and ductwork, is not included (EPA, 2000). Pollutants that require an unusually high level of control or that require the filter media or the unit itself to be constructed of special materials, such as Nomex® or stainless steel, will increase the costs of the system (EPA, 1998a). The additional costs for controlling more complex waste streams are not reflected in the estimates given below. For these types of systems, the capital cost could increase by as much as 75% and the O&M cost could increase by as much as 10%. In general, a small unit controlling a low pollutant loading will not be as cost effective as a large unit controlling a high pollutant loading (EPA, 2000).

AT-A-GLANCE TABLE FOR POINT SOURCES

Cartridge filters contain either a paper or nonwoven fibrous filter media (EPA, 2000). Paper media is generally made of materials such as cellulose and fiberglass. The dust cake that forms on the filter media from the collected PM can significantly increase collection efficiency (EPA, 1998b).

In general, the filter media is pleated to provide a larger surface area to volume flow rate. Close pleating, however, can cause PM to bridge the pleat bottom, effectively reducing the surface collection area (EPA, 1998b). Corrugated aluminum separators are used to prevent the pleats from collapsing (Heumann, 1997). There are variety of cartridge designs and dimensions. Typical designs include flat panels, V-shaped packs or cylindrical packs (Heumann, 1997). For certain applications, two cartridges may be placed in series.

Cartridge collectors are useful for collecting particles with resistivities either too low or too high for collection with electrostatic precipitators (STAPPA/ALAPCO, 1996). For similar air flow rates, cartridge collectors are compact in size compared to traditional bag

References:

EPA, 1998b: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, Chapter 5, EPA 453/B-96-001, Research Triangle Park, NC. December 1998.

EPA, 1998a: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

EPA, 2000: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Cartridge Collector with Pulse-Jet Cleaning," April 2000.

Heumann, 1997: W. L. Heumann, "Industrial Air Pollution Control Systems," McGraw Hill Publishers, Inc., Washington, D.C., 1997.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

STAPPA/ALAPCO, 1996: State and Territorial Air Pollution Program Administrators and Association of Local Air Pollution Control Officials, "Controlling Particulate Matter Under the Clean Air Act: A Menu of Options," July 1996.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Fabricated Metal Products - Welding

Control Measure Name: Paper/Nonwoven Filters - Cartridge Collector Type

Rule Name: Not Applicable

Pechan Measure Code: P2291

POD: 229

Application: This control is the use of paper or non-woven filters (cartridge collector type) to reduce PM emissions. The waste gas stream is passed through the fibrous filter media causing PM in the gas stream to be collected on the media by sieving and other mechanisms.

This control measure applies to welding operations as a part of fabricated metal products processing and production, classified under SCCs 30900501 and 30904001.

Affected SCC:

30900501 Welding, Arc Welding: General ** (See 3-09-050)

30904001 Fabricated Metal Products, Metal Deposition, Metallizing-Wire Atomization & Spraying

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 99% from uncontrolled for both PM10 and PM2.5

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs are generated using EPA's cost-estimating spreadsheets for fabric filters (EPA, 1998a). Costs are primarily driven by the waste stream volumetric flow rate and pollutant loading. When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan,2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 2000). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

AT-A-GLANCE TABLE FOR POINT SOURCES

Capital Costs:

Range from \$7 to \$13 per scfm
Typical value is \$9 per scfm

O&M Costs:

Range from \$9 to \$25 per scfm
Typical value is \$14 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). O&M costs were calculated for three model plants with flow rates of 25, 75 and 150 thousand acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust loading of 4.0 grains per cubic feet. The operating time was assumed to be 8760 hours per year. An average cartridge cost was estimated using the costs for standard cartridge types. Capital recovery for the periodic replacement of cartridges was included in the O&M cost of the cartridges using a cartridge life of 2 years (EPA, 1998a). The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.0671	\$/kW-hr
Compressed air	0.25	\$/1000 scf
Dust disposal	25	\$/ton disposed

Note: All costs are in 1998 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$85 to \$256 per ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$142 per ton PM10 reduced. (1998\$)

Comments:

Status: Demonstrated	Last Reviewed: 2001
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Additional Information:

The cost estimates assume a conventional design under typical operating conditions. Auxiliary equipment, such as fans and ductwork, is not included (EPA, 2000). Pollutants that require an unusually high level of control or that require the filter media or the unit itself to be constructed of special materials, such as Nomex ® or stainless steel, will increase the costs of the system (EPA, 1998a). The additional costs for controlling more complex waste streams are not reflected in the estimates given below. For these types of systems, the capital cost could increase by as much as 75% and the O&M cost could increase by as much as 10%. In general, a small unit controlling a low pollutant loading will not be as cost effective as a large unit controlling a high pollutant loading (EPA, 2000).

Cartridge filters contain either a paper or nonwoven fibrous filter media (EPA, 2000). Paper media is generally made of materials such as cellulose and fiberglass. The dust cake that forms on the filter media from the collected PM can significantly increase collection efficiency (EPA, 1998b).

In general, the filter media is pleated to provide a larger surface area to volume flow rate. Close

AT-A-GLANCE TABLE FOR POINT SOURCES

pleating, however, can cause PM to bridge the pleat bottom, effectively reducing the surface collection area (EPA, 1998b). Corrugated aluminum separators are used to prevent the pleats from collapsing (Heumann, 1997). There are variety of cartridge designs and dimensions. Typical designs include flat panels, V-shaped packs or cylindrical packs (Heumann, 1997). For certain applications, two cartridges may be placed in series.

Cartridge collectors are useful for collecting particles with resistivities either too low or too high for collection with electrostatic precipitators (STAPPA/ALAPCO, 1996). For similar air flow rates, cartridge collectors are compact in size compared to traditional bag

References:

EPA, 1998b: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, Chapter 5, EPA 453/B-96-001, Research Triangle Park, NC. December 1998.

EPA, 1998a: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

EPA, 2000: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Cartridge Collector with Pulse-Jet Cleaning," April 2000.

Heumann, 1997: W. L. Heumann, "Industrial Air Pollution Control Systems," McGraw Hill Publishers, Inc., Washington, D.C., 1997.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

STAPPA/ALAPCO, 1996: State and Territorial Air Pollution Program Administrators and Association of Local Air Pollution Control Officials, "Controlling Particulate Matter Under the Clean Air Act: A Menu of Options," July 1996.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Ferrous Metals Processing - Coke

Control Measure Name: Fabric Filter (Mech. Shaker Type)

Rule Name: Not Applicable

Pechan Measure Code: P2131

POD: 213

Application: This control is the addition of a mechanical shaker type fabric filter to reduce PM emissions. In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. The gas stream is drawn from beneath a cell plate in the floor and into the filter bags. The gas proceeds from the inside to the outside of the filter bags. The particles collect on the inside of the bags, forming a filter cake. In mechanical shaking units, the tops of bags are attached to a shaker bar, moved briskly to clean the bags.

This control applies to by-product coke metal processing operations.

Affected SCC:

30300302 Primary Metal Production, By-product Coke Manufacturing, Oven Charging
30300303 By-product Coke Manufacturing, Oven Pushing
30300304 By-product Coke Manufacturing, Quenching
30300305 By-product Coke Manufacturing, Coal Unloading
30300306 By-product Coke Manufacturing, Oven Underfiring
30300307 By-product Coke Manufacturing, Coal Crushing/Handling
30300308 By-product Coke Manufacturing, Oven/Door Leaks
30300309 By-product Coke Manufacturing, Coal Conveying
30300310 By-product Coke Manufacturing, Coal Crushing
30300312 By-product Coke Manufacturing, Coke: Crushing/Screening/Handling
30300313 By-product Coke Manufacturing, Coal Preheater
30300314 By-product Coke Manufacturing, Topside Leaks
30300315 Primary Metal Production, By-product Coke Manufacturing, Gas By-product Plant
30300316 By-product Coke Manufacturing, Coal Storage Pile
30300334 By-product Coke Manufacturing, Tar Dehydrator
30300399 By-product Coke Manufacturing, Not Classified **
30300401 Coke Manufacture: Beehive Process, General

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 99% from uncontrolled for both PM10 and PM2.5

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs for mechanical shaker cleaned systems are generated using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan,2001).

AT-A-GLANCE TABLE FOR POINT SOURCES

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 1990). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$8 to \$71 per scfm
Typical value is \$29 per scfm

O&M Costs:

Range from \$4 to \$24 per scfm
Typical value is \$11 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). O&M costs were calculated for three model plants with flow rates of 25, 75 and 150 thousand acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust loading of 4.0 grains per cubic feet. The operating time was assumed to be 8760 hours per year. An average bag cost was estimated using the costs for standard bag types. Capital recovery for the periodic replacement of bags was included in the O&M cost of the bags using a bag life of 2 years (EPA, 1998a). The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.0671	\$/kW-hr
Compressed air	0.25	\$/1000 scf
Dust disposal	25	\$/ton disposed

Note: All costs are in 1998 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$37 to \$303 per ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$126 per ton PM10 reduced. (1998\$)

Comments:

Status: Demonstrated

Last Reviewed: 2001

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

By product coke production is used to manufacture metallurgical coke by heating high-grade bituminous coal (low sulfur and low ash) in an enclosed oven chamber without oxygen. The resulting solid material consists of elemental carbon and any minerals (ash) that were present in the coal blend that did not volatilize during the process. Sources of air emissions consist of coke oven doors, coke oven lids and off-takes, coke oven charging, coke oven pushing, coke oven underfire stack, coke quenching, battery venting, and coke by-product-recovery plants.

Cost estimates assume a conventional design under typical operating conditions. The costs do not include auxiliary equipment such as fans and ductwork. (EPA, 2000)

Costs are primarily based on volumetric flow rate and the amount of PM in the waste stream. In general, a small unit controlling a low pollutant levels will not be as cost effective as a large unit controlling a high pollutant levels. (EPA, 2000)

Pollutants requiring a high level of control or the fabric filters to be constructed of special materials will increase the costs of the system (EPA, 1998a). The additional costs for controlling complex waste streams are not included in the estimates. For these systems, the capital cost could increase by as much as 30% and the O&M cost could increase by as much as 7%.

In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Fabric filters may be in the form of sheets, cartridges, or bags, with many individual filter units together in a group. Bags are the most common type of filter. The dust cake that forms on the filter from the collected PM can significantly increase collection efficiency. (EPA, 2000)

Mechanical shaking is a popular cleaning method because it is both simple and effective. In typical operation, dusty gas enters an inlet pipe to the fabric filter and very large particles are removed using a baffle plate fall into the hopper. The gas stream is drawn from beneath a cell plate in the floor and into the filter bags (EPA, 2000). The gas proceeds from the inside to the outside of the filter bags. The particles collect on the inside of the bags, forming a filter cake. In mechanical shaking units, the tops of bags are attached to a shaker bar, moved briskly (usually in a horizontal direction) to clean the bags. The shaker bars are operated by mechanical motors or by hand (EPA, 1998b)..

Fabric filters are useful for collecting particles with resistivities either too low or too high for collection with electrostatic precipitators. Fabric filters are useful in controlling particulate matter less than or equal to 10 micrometers (μm) in diameter (PM₁₀) and particulate matter less than or equal to 2.5 μm in diameter (PM_{2.5}). Fabric filters may be good candidates for collecting fly ash from low-sulfur coals or containing high unburned carbon levels and are relatively difficult to collect with electrostatic precipitators. (EPA, 2000)

References:

EPA, 1998a: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, Chapter 5, EPA 453/B-96-001, Research Triangle Park, NC. December 1998.

EPA, 1998b: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

EPA, 2000: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution

AT-A-GLANCE TABLE FOR POINT SOURCES

Technology Fact Sheet - Fabric Filter - Mechanical Shaker Cleaned Type," August 2000.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Ferrous Metals Processing - Coke

Control Measure Name: Fabric Filter (Reverse-Air Cleaned Type)

Rule Name: Not Applicable

Pechan Measure Code: P2132

POD: 213

Application: This control is the use of a reverse-air cleaned fabric filter to reduce PM emissions from waste streams. In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Reverse-air cleaning is performed by forcing clean air through the filters in the opposite direction of the dusty gas flow. The change in direction of the gas flow causes the bag to flex and crack the filter cake allowing for internal cake collection.

This control applies to by-product coke metal processing operations.

Affected SCC:

30300302 Primary Metal Production, By-product Coke Manufacturing, Oven Charging
30300303 By-product Coke Manufacturing, Oven Pushing
30300304 By-product Coke Manufacturing, Quenching
30300305 By-product Coke Manufacturing, Coal Unloading
30300306 By-product Coke Manufacturing, Oven Underfiring
30300307 By-product Coke Manufacturing, Coal Crushing/Handling
30300308 By-product Coke Manufacturing, Oven/Door Leaks
30300309 By-product Coke Manufacturing, Coal Conveying
30300310 By-product Coke Manufacturing, Coal Crushing
30300312 By-product Coke Manufacturing, Coke: Crushing/Screening/Handling
30300313 By-product Coke Manufacturing, Coal Preheater
30300314 By-product Coke Manufacturing, Topside Leaks
30300315 Primary Metal Production, By-product Coke Manufacturing, Gas By-product Plant
30300316 By-product Coke Manufacturing, Coal Storage Pile
30300334 By-product Coke Manufacturing, Tar Dehydrator
30300399 By-product Coke Manufacturing, Not Classified **
30300401 Coke Manufacture: Beehive Process, General

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 99% from uncontrolled for both PM10 and PM2.5

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs for reverse-air cleaned systems are generated using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan,2001).

AT-A-GLANCE TABLE FOR POINT SOURCES

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 2000). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$9 to \$84 per scfm
Typical value is \$34 per scfm

O&M Costs:

Range from \$6 to \$27 per scfm
Typical value is \$13 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). O&M costs were calculated for three model plants with flow rates of 25, 75 and 150 thousand acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust loading of 4.0 grains per cubic feet. The operating time was assumed to be 8760 hours per year. An average bag cost was estimated using the costs for standard bag types. Capital recovery for the periodic replacement of bags was included in the O&M cost of the bags using a bag life of 2 years (EPA, 1998a). The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.0671	\$/kW-hr
Compressed air	0.25	\$/1000 scf
Dust disposal	25	\$/ton disposed

Note: All costs are in 1998 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$53 to \$337 per ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$148 per ton PM10 reduced. (1998\$)

Comments:

Status: Demonstrated

Last Reviewed: 2001

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

By product coke production is used to manufacture metallurgical coke by heating high-grade bituminous coal (low sulfur and low ash) in an enclosed oven chamber without oxygen. The resulting solid material consists of elemental carbon and any minerals (ash) that were present in the coal blend that did not volatilize during the process. Sources of air emissions consist of coke oven doors, coke oven lids and off-takes, coke oven charging, coke oven pushing, coke oven underfire stack, coke quenching, battery venting, and coke by-product-recovery plants.

The cost estimates assume a conventional design under typical operating conditions. The costs do not include any auxiliary equipment (EPA, 2000).

The capital cost for the reverse-jet cleaned fabric baghouse is based on information provided by a manufacturer (EPA, 2000). The capital cost includes only the purchased equipment cost.

Costs are primarily based on volumetric flow rate and the amount of PM in the waste stream. In general, a small unit controlling a low pollutant levels will not be as cost effective as a large unit controlling a high pollutant levels. (EPA, 2000)

Pollutants requiring a high level of control or the fabric filters to be constructed of special materials will increase the costs of the system (EPA, 1998a). The additional costs for controlling complex streams are not reflected in the estimates. For these systems, the capital cost could increase by as much as 40% and the O&M cost could increase by as much as 5%. (EPA, 2000)

In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Fabric filters may be in the form of sheets, cartridges, or bags, with many individual filter units together in a group. Bags are the most common type of filter. The dust cake that forms on the filter from the collected PM can significantly increase collection efficiency. (EPA, 2000)

Reverse-air cleaning is a popular filter cleaning method as it has been used extensively and improved over the years. It is a gentler but sometimes less effective clearing mechanism than mechanical shaking. Reverse-air cleaning is performed by forcing clean air through the filters in the opposite direction of the dusty gas flow. The change in direction of the gas flow causes the bag to flex and crack the filter cake allowing for internal cake collection (EPA, 2000).

The most common design is to have separate compartments within the fabric filter so that each can be isolated and cleaned separately while the others continue to treat the dusty gas. There are several methods of reversing the flow through the filters. One method of providing the reverse flow is by the use of a fan or cleaned gas from other compartments. Reverse-air cleaning only used alone in cases where the dust releases easily from the fabric. In many instances, reverse-air is used along with shaking, pulsing or sonic horns (EPA, 1998b).

Fabric filters are useful for collecting particles with resistivities either too low or too high for collection with electrostatic precipitators. Fabric filters are useful in controlling particulate matter less than or equal to 10 micrometers (μm) in diameter (PM₁₀) and particulate matter less than or equal to 2.5 μm in diameter (PM_{2.5}). Fabric filters may be good candidates for collecting fly ash from low-sulfur coals or containing high unburned carbon levels and are relatively difficult to collect with electrostatic precipitators. (EPA, 2000)

AT-A-GLANCE TABLE FOR POINT SOURCES

References:

EPA, 1998b: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter, EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

EPA, 1998a: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, Chapter 5, EPA 453/B-96-001, Research Triangle Park, NC. December 1998.

EPA, 2000: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Fabric Filter - Reverse-Air Cleaned Type," April 2000.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Ferrous Metals Processing - Coke

Control Measure Name: Venturi Scrubber

Rule Name: Not Applicable

Pechan Measure Code: P2133

POD: 213

Application: The control is the use of a venturi scrubber to reduce PM emissions. A scrubber is a type of technology that removes air pollutants by inertial and diffusional interception. A venturi scrubber accelerates the waste gas stream to atomize the scrubbing liquid and to improve gas-liquid contact.

This control applies to by-product coke metal processing operations.

Affected SCC:

30300302 Primary Metal Production, By-product Coke Manufacturing, Oven Charging
30300303 By-product Coke Manufacturing, Oven Pushing
30300304 By-product Coke Manufacturing, Quenching
30300305 By-product Coke Manufacturing, Coal Unloading
30300306 By-product Coke Manufacturing, Oven Underfiring
30300307 By-product Coke Manufacturing, Coal Crushing/Handling
30300308 By-product Coke Manufacturing, Oven/Door Leaks
30300312 By-product Coke Manufacturing, Coke: Crushing/Screening/Handling
30300314 By-product Coke Manufacturing, Topside Leaks
30300315 Primary Metal Production, By-product Coke Manufacturing, Gas By-product Plant
30300316 By-product Coke Manufacturing, Coal Storage Pile
30300334 By-product Coke Manufacturing, Tar Dehydrator
30300399 By-product Coke Manufacturing, Not Classified **
30300401 Coke Manufacture: Beehive Process, General

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: PM10 control efficiency is 93% from uncontrolled; PM2.5 control efficiency is 89% from uncontrolled

Equipment Life: 10 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The following are cost ranges for venturi wet scrubbers, developed using EPA cost-estimating spreadsheets (EPA, 1996) and referenced to the volumetric flow rate of the waste stream treated. When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan,2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative

AT-A-GLANCE TABLE FOR POINT SOURCES

costs was estimated as 4 percent of the total capital investment (EPA, 1999). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (10 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$3 to \$28 per scfm
Typical value is \$11 per scfm

O&M Costs:

Range from \$4 to \$119 per scfm
Typical value is \$42 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for Impingement Plate Scrubbers (EPA, 1996). O&M costs were calculated for two model plants with flow rates of 2,000 and 150,000 acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. The model plants were assumed to have a dust loading of 3.0 grains per cubic feet. The operating time was assumed to be 8760 hours per year. An inlet water flow rate for the scrubber was assumed to be 9.4 lbs/min. The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.067	\$/kW-hr
Process water price	0.20	\$/1000 gal
Dust disposal	25	\$/ton disposed
Wastewater treatment	3.8	\$/ thousand gal treated

Note: All costs are in 1995 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$76 to \$2,100 per ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$751 per ton PM10 reduced. (1995\$)

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

The costs do not include costs for post-treatment or disposal of used solvent or waste. Actual costs can be substantially higher than in the ranges shown for applications which require expensive materials, solvents, or treatment methods (EPA, 1999). As a rule, smaller units controlling a low

AT-A-GLANCE TABLE FOR POINT SOURCES

concentration waste stream will be much more expensive (per unit volumetric flow rate) than a large unit cleaning a high pollutant load flow.

By product coke production is used to manufacture metallurgical coke by heating high-grade bituminous coal (low sulfur and low ash) in an enclosed oven chamber without oxygen. The resulting solid material consists of elemental carbon and any minerals (ash) that were present in the coal blend that did not volatilize during the process. Sources of air emissions consist of coke oven doors, coke oven lids and off-takes, coke oven charging, coke oven pushing, coke oven underfire stack, coke quenching, battery venting, and coke by-product-recovery plants.

A venturi scrubber accelerates the waste gas stream to improve gas-liquid contact. In a venturi scrubber, a "throat" section is built into the duct that forces the gas stream to accelerate (EPA, 1999). As the gas enters the venturi throat, both gas velocity and turbulence increase.

After the throat section, the mixture decelerates, and further impacts occur causing the droplets to agglomerate. Once the particles have been captured by the liquid, the wetted PM and excess liquid are separated from the gas stream through entrainment. This section usually consists of a cyclonic separator and/or a mist eliminator (EPA, 1998; Corbitt, 1990).

For PM applications, wet scrubbers generate waste, either a slurry or wet sludge. This creates the need for both wastewater treatment and solid waste disposal. Initially, the slurry is treated to separate the solid waste from the water (EPA, 1999). The treated water can then be reused or discharged. Once the water is removed, the remaining waste will be in the form of a solid or sludge. If the solid waste is inert and nontoxic, it can generally be land filled. Hazardous wastes will have more stringent procedures for disposal. In some cases, the solid waste may have value and can be sold or recycled (EPA, 1998).

References:

Corbitt, 1990: "Standard Handbook of Environmental Engineering," edited by Robert A. Corbitt, McGraw-Hill, New York, NY, 1990.

EPA, 1996: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, EPA 453/B-96-001, Research Triangle Park, NC February.

EPA, 1998: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

EPA, 1999: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Venturi Scrubber," July 1999.

Heumann, 1997: W. L. Heumann, "Industrial Air Pollution Control Systems," McGraw Hill Publishers, Inc., Washington, D.C., 1997.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

STAPPA/ALAPCO, 1996: State and Territorial Air Pollution Program Administrators and Association of Local Air Pollution Control Officials, "Controlling Particulate Matter Under the Clean Air Act: A Menu of Options," July 1996.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Ferrous Metals Processing - Coke

Control Measure Name: Increased Monitoring Frequency (IMF) of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P3213

POD: 213

Application: This measure is to conduct improved monitoring for PM_{2.5} emissions at stationary sources. Improved monitoring in this case means increasing the monitoring frequency of electrostatic precipitators, scrubbers, and fabric filters from once per day to four times per hour, with no change in monitoring technique.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (Barr and Schaffner) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

303003 Primary Metal Production, By-product Coke Manufacturing

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 6.5% for both PM₁₀ and PM_{2.5}

Equipment Life: Not applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs included the incremental record keeping and reporting associated with the increased monitoring frequency. Labor rates for 2003 were made that were obtained from the Bureau of Labor Statistics (labor rates include 140 percent overhead). The incremental costs included a one-time cost for development of the improved monitoring and recurring annual burden costs for incremental record keeping, reporting, and certification activities.

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$620 per ton PM reduced (2003\$).

Comments:

Status:

Last Reviewed: 2004

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM2.5 Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 2003.

BLS, 2003: Bureau of Labor Statistics, "Employer Costs for Employee Compensation – June 2003," Table 12, page 16, 2003.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Ferrous Metals Processing - Coke

Control Measure Name: CEM Upgrade and Increased Monitoring Frequency of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P4213

POD: 213

Application: This measure examines the impacts of improving the PM monitoring technique at units currently using an ESP, scrubber, or fabric filter. In this improved technique scenario, the monitoring technique is upgraded to a PM continuous emission monitor. This improved monitoring technique also results in an increase to the monitoring frequency because a PM CEMS can make a measurement every 7.5 minutes. The monitoring frequency increases from once per day to eight times per hour.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (see References) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

303003 Primary Metal Production, By-product Coke Manufacturing

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 7.7% for both PM10 and PM2.5

Equipment Life: Unknown

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The total capital and annual operating costs for implementing an improved monitoring technique are calculated based on data from the EPA CEMS Cost Model and the PM CEMS Knowledge document. Labor rates in the EPA CEMS Cost Model are scaled to reflect 2003 labor rates (including 140 percent overhead) provided by the Bureau of Labor Statistics.

The cost effectiveness at a percent excess emission rate of 0.46 percent is \$5,200 per ton of PM2.5. This is based on a \$34 million capital investment cost, and a \$14 million total annualized cost when applied to 128 facilities.

Note: All costs are in 2003 dollars.

AT-A-GLANCE TABLE FOR POINT SOURCES

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$5,200 per ton PM reduced (2003\$).

Comments:

Status:

Last Reviewed: 2004

Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM_{2.5} Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 8, 2003.

EPA CEMS Cost Model, Version 3.0, U.S. Environmental Protection Agency.

EPA, 2000: U.S. Environmental Protection Agency, "Current Knowledge of Particulate Matter (PM) Continuous Emissions Monitoring," Chapter 9, PM CEMS Cost, September 8, 2000.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Ferrous Metals Processing - Ferroalloy Production

Control Measure Name: Fabric Filter (Mech. Shaker Type)

Rule Name: Not Applicable

Pechan Measure Code: P2141

POD: 214

Application: This control is the addition of a mechanical shaker type fabric filter to reduce PM emissions. In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. The gas stream is drawn from beneath a cell plate in the floor and into the filter bags. The gas proceeds from the inside to the outside of the filter bags. The particles collect on the inside of the bags, forming a filter cake. In mechanical shaking units, the tops of bags are attached to a shaker bar, moved briskly to clean the bags.

This control applies to ferroalloy production operations, including (but not limited to) several processes within this industry were selected for control, basic oxygen process furnace (SCC 30300914) and EAF argon O2 decarb vessels (SCC 30300928).

Affected SCC:

30300601 Ferroalloy, Open Furnace, 50% FeSi: Electric Smelting Furnace
30300602 Ferroalloy, Open Furnace, 75% FeSi: Electric Smelting Furnace
30300604 Ferroalloy, Open Furnace, Silicon Metal: Electric Smelting Furnace
30300605 Ferroalloy, Open Furnace, Silicomanganese: Electric Smelting Furnace
30300610 Ferroalloy, Open Furnace, Ore Screening
30300613 Ferroalloy, Open Furnace, Raw Material Storage
30300621 Ferroalloy, Open Furnace, Casting
30300623 Ferroalloy, Open Furnace, Product Crushing
30300624 Ferroalloy, Open Furnace, Product Storage
30300699 Ferroalloy, Open Furnace, Other Not Classified
30300701 Ferroalloy, Semi-covered Furnace, Ferromanganese: Electric Arc Furnace
30300702 Ferroalloy, Semi-covered Furnace, Electric Arc Furnace: Other Alloys/Specify

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 99% from uncontrolled for both PM10 and PM2.5

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs for mechanical shaker cleaned systems are generated using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan,2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and

AT-A-GLANCE TABLE FOR POINT SOURCES

administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 2000). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$8 to \$71 per scfm
Typical value is \$29 per scfm

O&M Costs:

Range from \$4 to \$24 per scfm
Typical value is \$11 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). O&M costs were calculated for three model plants with flow rates of 25, 75 and 150 thousand acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust loading of 4.0 grains per cubic feet. The operating time was assumed to be 8760 hours per year. An average bag cost was estimated using the costs for standard bag types. Capital recovery for the periodic replacement of bags was included in the O&M cost of the bags using a bag life of 2 years (EPA, 1998a). The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.0671	\$/kW-hr
Compressed air	0.25	\$/1000 scf
Dust disposal	25	\$/ton disposed

Note: All costs are in 1998 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$37 to \$303 per ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$126 per ton PM10 reduced. (1998\$)

Comments:

Status: Demonstrated	Last Reviewed: 2001
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AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

Steel normally is produced in either basic oxygen process furnaces or electric arc furnaces. In the basic oxygen process furnace, a mixture of 70 percent molten iron from the blast furnace and 30 percent iron scrap are melted together. Pure oxygen is blown across the top or through the molten steel to oxidize carbon and oxygen impurities, thus removing these from the steel. Basic oxygen process furnaces are large open-mouthed furnaces that can be tilted to accept a charge or to tap the molten steel to a charging ladle for transfer to an ingot mold or continuous caster.

Because basic oxygen furnaces are open, they produce significant uncontrolled particulate emissions, notably during the refining stage when oxygen is being blown. Electric arc furnaces use the current passing between carbon electrodes to heat molten steel, but also use oxy-fuel burners to accelerate the initial melting process. These furnaces are charged largely with scrap iron. Significant emissions occur during charging, when the furnace roof is open, during melting, as the electrodes are lowered into the scrap and the arc is struck, and during tapping, when alloying elements are added to the melt.

Cost estimates assume a conventional design under typical operating conditions. The costs do not include auxiliary equipment such as fans and ductwork. (EPA, 2000)

Costs are primarily based on volumetric flow rate and the amount of PM in the waste stream. In general, a small unit controlling a low pollutant levels will not be as cost effective as a large unit controlling a high pollutant levels. (EPA, 2000)

Pollutants requiring a high level of control or the fabric filters to be constructed of special materials will increase the costs of the system (EPA, 1998a). The additional costs for controlling complex waste streams are not included in the estimates. For these systems, the capital cost could increase by as much as 30% and the O&M cost could increase by as much as 7%.

In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Fabric filters may be in the form of sheets, cartridges, or bags, with many individual filter units together in a group. Bags are the most common type of filter. The dust cake that forms on the filter from the collected PM can significantly increase collection efficiency. (EPA, 2000)

Mechanical shaking is a popular cleaning method because it is both simple and effective. In typical operation, dusty gas enters an inlet pipe to the fabric filter and very large particles are removed using a baffle plate fall into the hopper. The gas stream is drawn from beneath a cell plate in the floor and into the filter bags (EPA, 2000). The gas proceeds from the inside to the outside of the filter bags. The particles collect on the inside of the bags, forming a filter cake. In mechanical shaking units, the tops of bags are attached to a shaker bar, moved briskly (usually in a horizontal direction) to clean the bags. The shaker bars are operated by mechanical motors or by hand (EPA, 1998b)..

Fabric filters are useful for collecting particles with resistivities either too low or too high for collection with electrostatic precipitators. Fabric filters are useful in controlling particulate matter less than or equal to 10 micrometers (μm) in diameter (PM₁₀) and particulate matter less than or equal to 2.5 μm in diameter (PM_{2.5}). Fabric filters may be good candidates for collecting fly ash from low-sulfur coals or containing high unburned carbon levels and are relatively difficult to collect with electrostatic precipitators. (EPA, 2000)

AT-A-GLANCE TABLE FOR POINT SOURCES

References:

EPA, 1998a: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, Chapter 5, EPA 453/B-96-001, Research Triangle Park, NC. December 1998.

EPA, 1998b: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

EPA, 2000: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Fabric Filter - Mechanical Shaker Cleaned Type," August 2000.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Ferrous Metals Processing - Ferroalloy Production

Control Measure Name: Dry ESP-Wire Plate Type

Rule Name: Not Applicable

Pechan Measure Code: P2142

POD: 214

Application: This control is the use of dry electrostatic precipitators (ESP) to reduce PM emissions. An ESP uses electrical forces to move particles in an exhaust stream onto collector plates. Electrodes in the center of the flow are maintained at high voltage and generate an electrical field forcing particles to the collector walls. In dry ESPs, the collectors are knocked by various mechanical means to dislodge the particulate, which slides downward into a hopper.

This control applies to ferroalloy production operations, including (but not limited to) several processes within this industry were selected for control, basic oxygen process furnace (SCC 30300914) and EAF argon O2 decarb vessels (SCC 30300928).

Affected SCC:

30300601 Ferroalloy, Open Furnace, 50% FeSi: Electric Smelting Furnace
30300602 Ferroalloy, Open Furnace, 75% FeSi: Electric Smelting Furnace
30300604 Ferroalloy, Open Furnace, Silicon Metal: Electric Smelting Furnace
30300605 Ferroalloy, Open Furnace, Silicomanganese: Electric Smelting Furnace
30300610 Ferroalloy, Open Furnace, Ore Screening
30300613 Ferroalloy, Open Furnace, Raw Material Storage
30300621 Ferroalloy, Open Furnace, Casting
30300623 Ferroalloy, Open Furnace, Product Crushing
30300624 Ferroalloy, Open Furnace, Product Storage
30300699 Ferroalloy, Open Furnace, Other Not Classified
30300701 Ferroalloy, Semi-covered Furnace, Ferromanganese: Electric Arc Furnace
30300702 Ferroalloy, Semi-covered Furnace, Electric Arc Furnace: Other Alloys/Specify

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: PM10 control efficiency is 98% from uncontrolled; PM2.5 control efficiency is 95% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs for ESPs of conventional design under typical operating conditions are developed using EPA cost estimating spreadsheets (EPA, 1996). When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan, 2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and

AT-A-GLANCE TABLE FOR POINT SOURCES

administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 1999). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$15 to \$50 per scfm
Typical value is \$27 per scfm

O&M Costs:

Range from \$4 to \$40 per scfm
Typical value is \$16 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for ESP (EPA, 1996). O&M costs were calculated for three model plants with flow rates of 200 and 500 thousand acfm and 1 million acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust loading of 6.0 grains per cubic feet. The operating time was assumed to be 8640 hours per year. The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.067	\$/kW-hr
Dust disposal	25	\$/ton disposed

Note: All costs are in 1995 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$40 to \$250 per ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$110 per ton PM10 reduced. (1995\$)

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

In the wire-plate ESP, the gas flows around vertical, metal plates. The electrodes are long, weighted wires hanging between the plates. The voltage applied to the electrodes causes the gas between the electrodes to break down, known as a "corona." The electrodes are most often given a negative polarity because a negative corona supports a higher voltage than a positive corona.

AT-A-GLANCE TABLE FOR POINT SOURCES

Certain types of losses affect control efficiency. The dislodging of the accumulated layer also projects some of the particles back into the gas stream. These particles are processed in later sections of the ESP, but the particles from the last section have no chance to be recaptured. Due to the space needed at the top of the ESP for nonelectrified components, part of the stream may flow around the charged zones. This is called "sneakage" and places an upper limit on the collection efficiency of the ESP. Anti-sneakage baffles are used to force the sneakage flow to mix with the main gas stream for collection in later sections (EPA, 1998).

Another factor in the performance of ESPs is the resistivity of the collected material. All the ion current must pass through the collected layer to reach the ground plates. This creates an electric field in the layer, and it can become large enough to cause electrical breakdown. When this occurs, new ions of the wrong polarity are injected into the wire-plate gap reducing the charge on the particles, which may cause sparking. This condition is called "back corona." When this happens the collection ability of the unit is reduced. At low resistivities the particles are held on the plates so loosely that reentrainment levels are much higher. Hence, care must be taken in measuring or estimating resistivity because it is strongly affected by such variables as temperature, moisture, gas composition, particle composition, and surface characteristics (EPA, 1999).

Dusts with high resistivities are also not well-suited for collection in dry ESPs. These particles are not easily charged nor easily collected. High-resistivity particles form ash layers with very high voltage gradients on the collecting electrodes lead to back corona, reducing the charge on particles and lowering collection efficiency. Fly ash from the combustion of low-sulfur coal typically has a high resistivity, and thus is difficult to collect using dry ESPs (EPA, 1999).

References:

EPA, 1996: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, EPA 453/B-96-001, Research Triangle Park, NC. February 1996.

EPA, 1998: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

EPA, 1999: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Dry Electrostatic Precipitator (ESP) - Wire-Plate Type," May 1999.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Ferrous Metals Processing - Ferroalloy Production

Control Measure Name: Fabric Filter (Reverse-Air Cleaned Type)

Rule Name: Not Applicable

Pechan Measure Code: P2143

POD: 214

Application: This control is the use of a reverse-air cleaned fabric filter to reduce PM emissions from waste streams. In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Reverse-air cleaning is performed by forcing clean air through the filters in the opposite direction of the dusty gas flow. The change in direction of the gas flow causes the bag to flex and crack the filter cake allowing for internal cake collection.

This control applies to ferroalloy production operations, including (but not limited to) several processes within this industry were selected for control, basic oxygen process furnace (SCC 30300914) and EAF argon O2 decarb vessels (SCC 30300928).

Affected SCC:

30300601 Ferroalloy, Open Furnace, 50% FeSi: Electric Smelting Furnace
30300602 Ferroalloy, Open Furnace, 75% FeSi: Electric Smelting Furnace
30300604 Ferroalloy, Open Furnace, Silicon Metal: Electric Smelting Furnace
30300605 Ferroalloy, Open Furnace, Silicomanganese: Electric Smelting Furnace
30300610 Ferroalloy, Open Furnace, Ore Screening
30300613 Ferroalloy, Open Furnace, Raw Material Storage
30300621 Ferroalloy, Open Furnace, Casting
30300623 Ferroalloy, Open Furnace, Product Crushing
30300624 Ferroalloy, Open Furnace, Product Storage
30300699 Ferroalloy, Open Furnace, Other Not Classified
30300701 Ferroalloy, Semi-covered Furnace, Ferromanganese: Electric Arc Furnace
30300702 Ferroalloy, Semi-covered Furnace, Electric Arc Furnace: Other Alloys/Specify

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 99% from uncontrolled for both PM10 and PM2.5

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs for reverse-air cleaned systems are generated using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan,2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative

AT-A-GLANCE TABLE FOR POINT SOURCES

costs was estimated as 4 percent of the total capital investment (EPA, 2000). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$9 to \$84 per scfm
Typical value is \$34 per scfm

O&M Costs:

Range from \$6 to \$27 per scfm
Typical value is \$13 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). O&M costs were calculated for three model plants with flow rates of 25, 75 and 150 thousand acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust loading of 4.0 grains per cubic feet. The operating time was assumed to be 8760 hours per year. An average bag cost was estimated using the costs for standard bag types. Capital recovery for the periodic replacement of bags was included in the O&M cost of the bags using a bag life of 2 years (EPA, 1998a). The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.0671	\$/kW-hr
Compressed air	0.25	\$/1000 scf
Dust disposal	25	\$/ton disposed

Note: All costs are in 1998 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$53 to \$337 per ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$148 per ton PM10 reduced. (1998\$)

Comments:

Status: Demonstrated

Last Reviewed: 2001

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

Steel normally is produced in either basic oxygen process furnaces or electric arc furnaces. In the basic oxygen process furnace, a mixture of 70 percent molten iron from the blast furnace and 30 percent iron scrap are melted together. Pure oxygen is blown across the top or through the molten steel to oxidize carbon and oxygen impurities, thus removing these from the steel. Basic oxygen process furnaces are large open-mouthed furnaces that can be tilted to accept a charge or to tap the molten steel to a charging ladle for transfer to an ingot mold or continuous caster.

Because basic oxygen furnaces are open, they produce significant uncontrolled particulate emissions, notably during the refining stage when oxygen is being blown. Electric arc furnaces use the current passing between carbon electrodes to heat molten steel, but also use oxy-fuel burners to accelerate the initial melting process. These furnaces are charged largely with scrap iron. Significant emissions occur during charging, when the furnace roof is open, during melting, as the electrodes are lowered into the scrap and the arc is struck, and during tapping, when alloying elements are added to the melt.

The cost estimates assume a conventional design under typical operating conditions. The costs do not include any auxiliary equipment (EPA, 2000).

The capital cost for the reverse-jet cleaned fabric baghouse is based on information provided by a manufacturer (EPA, 2000). The capital cost includes only the purchased equipment cost.

Costs are primarily based on volumetric flow rate and the amount of PM in the waste stream. In general, a small unit controlling a low pollutant levels will not be as cost effective as a large unit controlling a high pollutant levels. (EPA, 2000)

Pollutants requiring a high level of control or the fabric filters to be constructed of special materials will increase the costs of the system (EPA, 1998a). The additional costs for controlling complex streams are not reflected in the estimates. For these systems, the capital cost could increase by as much as 40% and the O&M cost could increase by as much as 5%. (EPA, 2000)

In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Fabric filters may be in the form of sheets, cartridges, or bags, with many individual filter units together in a group. Bags are the most common type of filter. The dust cake that forms on the filter from the collected PM can significantly increase collection efficiency. (EPA, 2000)

Reverse-air cleaning is a popular filter cleaning method as it has been used extensively and improved over the years. It is a gentler but sometimes less effective clearing mechanism than mechanical shaking. Reverse-air cleaning is performed by forcing clean air through the filters in the opposite direction of the dusty gas flow. The change in direction of the gas flow causes the bag to flex and crack the filter cake allowing for internal cake collection (EPA, 2000).

The most common design is to have separate compartments within the fabric filter so that each can be isolated and cleaned separately while the others continue to treat the dusty gas. There are several methods of reversing the flow through the filters. One method of providing the reverse flow is by the use of a fan or cleaned gas from other compartments. Reverse-air cleaning only used alone in cases where the dust releases easily from the fabric. In many instances, reverse-air is used along with shaking, pulsing or sonic horns (EPA, 1998b).

Fabric filters are useful for collecting particles with resistivities either too low or too high for collection with electrostatic precipitators. Fabric filters are useful in controlling particulate matter less than or

AT-A-GLANCE TABLE FOR POINT SOURCES

equal to 10 micrometers (μm) in diameter (PM₁₀) and particulate matter less than or equal to 2.5 μm in diameter (PM_{2.5}). Fabric filters may be good candidates for collecting fly ash from low-sulfur coals or containing high unburned carbon levels and are relatively difficult to collect with electrostatic precipitators. (EPA, 2000)

References:

EPA, 1998b: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

EPA, 1998a: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, Chapter 5, EPA 453/B-96-001, Research Triangle Park, NC. December 1998.

EPA, 2000: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Fabric Filter - Reverse-Air Cleaned Type," April 2000.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Ferrous Metals Processing - Ferroalloy Production

Control Measure Name: Increased Monitoring Frequency (IMF) of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P3214

POD: 214

Application: This measure is to conduct improved monitoring for PM_{2.5} emissions at stationary sources. Improved monitoring in this case means increasing the monitoring frequency of electrostatic precipitators, scrubbers, and fabric filters from once per day to four times per hour, with no change in monitoring technique.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (Barr and Schaffner) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

303007** Ferroalloy, Semi-covered Furnace,
303006** Primary Metal Production, Ferroalloy, Open Furnace

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 6.5% for both PM₁₀ and PM_{2.5}

Equipment Life: Not applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs included the incremental record keeping and reporting associated with the increased monitoring frequency. Labor rates for 2003 were made that were obtained from the Bureau of Labor Statistics (labor rates include 140 percent overhead). The incremental costs included a one-time cost for development of the improved monitoring and recurring annual burden costs for incremental record keeping, reporting, and certification activities.

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$620 per ton PM reduced (2003\$).

Comments:

Status:

Last Reviewed: 2004

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM2.5 Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 2003.

BLS, 2003: Bureau of Labor Statistics, "Employer Costs for Employee Compensation – June 2003," Table 12, page 16, 2003.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Ferrous Metals Processing - Ferroalloy Production

Control Measure Name: CEM Upgrade and Increased Monitoring Frequency of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P4214

POD: 214

Application: This measure examines the impacts of improving the PM monitoring technique at units currently using an ESP, scrubber, or fabric filter. In this improved technique scenario, the monitoring technique is upgraded to a PM continuous emission monitor. This improved monitoring technique also results in an increase to the monitoring frequency because a PM CEMS can make a measurement every 7.5 minutes. The monitoring frequency increases from once per day to eight times per hour.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (see References) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

303007** Ferroalloy, Semi-covered Furnace,

303006** Primary Metal Production, Ferroalloy, Open Furnace

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 7.7% for both PM10 and PM2.5

Equipment Life: Unknown

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The total capital and annual operating costs for implementing an improved monitoring technique are calculated based on data from the EPA CEMS Cost Model and the PM CEMS Knowledge document. Labor rates in the EPA CEMS Cost Model are scaled to reflect 2003 labor rates (including 140 percent overhead) provided by the Bureau of Labor Statistics.

The cost effectiveness at a percent excess emission rate of 0.46 percent is \$5,200 per ton of PM2.5. This is based on a \$34 million capital investment cost, and a \$14 million total annualized cost when applied to 128 facilities.

Note: All costs are in 2003 dollars.

AT-A-GLANCE TABLE FOR POINT SOURCES

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$5,200 per ton PM reduced (2003\$).

Comments:

Status:

Last Reviewed: 2004

Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM_{2.5} Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 8, 2003.

EPA CEMS Cost Model, Version 3.0, U.S. Environmental Protection Agency.

EPA, 2000: U.S. Environmental Protection Agency, "Current Knowledge of Particulate Matter (PM) Continuous Emissions Monitoring," Chapter 9, PM CEMS Cost, September 8, 2000.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Ferrous Metals Processing - Gray Iron Foundries

Control Measure Name: Fabric Filter (Mech. Shaker Type)

Rule Name: Not Applicable

Pechan Measure Code: P2161

POD: 216

Application: This control is the addition of a mechanical shaker type fabric filter to reduce PM emissions. In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. The gas stream is drawn from beneath a cell plate in the floor and into the filter bags. The gas proceeds from the inside to the outside of the filter bags. The particles collect on the inside of the bags, forming a filter cake. In mechanical shaking units, the tops of bags are attached to a shaker bar, moved briskly to clean the bags.

This control applies to gray iron foundry operations.

Affected SCC:

30400301 Secondary Metal Production, Grey Iron Foundries, Cupola
30400302 Grey Iron Foundries, Reverberatory Furnace
30400303 Secondary Metal Production, Grey Iron Foundries, Electric Induction Furnace
30400304 Grey Iron Foundries, Electric Arc Furnace
30400305 Grey Iron Foundries, Annealing Operation
30400310 Secondary Metal Production, Grey Iron Foundries, Inoculation
30400315 Grey Iron Foundries, Charge Handling
30400318 Grey Iron Foundries, Pouring, Cooling
30400320 Secondary Metal Production, Grey Iron Foundries, Pouring/Casting
30400321 Grey Iron Foundries, Magnesium Treatment
30400322 Grey Iron Foundries, Refining
30400325 Grey Iron Foundries, Castings Cooling
30400331 Secondary Metal Production, Grey Iron Foundries, Casting Shakeout
30400333 Secondary Metal Production, Grey Iron Foundries, Shakeout Machine
30400340 Secondary Metal Production, Grey Iron Foundries, Grinding/Cleaning
30400341 Grey Iron Foundries, Casting Cleaning/Tumblers
30400350 Secondary Metal Production, Grey Iron Foundries, Sand Grinding/Handling
30400351 Secondary Metal Production, Grey Iron Foundries, Core Ovens
30400352 Secondary Metal Production, Grey Iron Foundries, Sand Grinding/Handling
30400353 Grey Iron Foundries, Core Ovens
30400357 Grey Iron Foundries, Conveyors/Elevators
30400358 Grey Iron Foundries, Sand Screens
30400360 Grey Iron Foundries, Castings Finishing
30400370 Grey Iron Foundries, Shell Core Machine
30400371 Grey Iron Foundries, Core Machines/Other
30400398 Grey Iron Foundries, Other Not Classified
30400399 Grey Iron Foundries, Other Not Classified

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 99% from uncontrolled for both PM10 and PM2.5

AT-A-GLANCE TABLE FOR POINT SOURCES

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs for mechanical shaker cleaned systems are generated using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan,2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 2000). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$8 to \$71 per scfm

Typical value is \$29 per scfm

O&M Costs:

Range from \$4 to \$24 per scfm

Typical value is \$11 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). O&M costs were calculated for three model plants with flow rates of 25, 75 and 150 thousand acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust loading of 4.0 grains per cubic feet. The operating time was assumed to be 8760 hours per year. An average bag cost was estimated using the costs for standard bag types. Capital recovery for the periodic replacement of bags was included in the O&M cost of the bags using a bag life of 2 years (EPA, 1998a). The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.0671	\$/kW-hr
Compressed air	0.25	\$/1000 scf

AT-A-GLANCE TABLE FOR POINT SOURCES

Dust disposal	25	\$/ton disposed
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Note: All costs are in 1998 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$37 to \$303 per ton PM₁₀ removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$126 per ton PM₁₀ reduced. (1998\$)

Comments:

Status: Demonstrated	Last Reviewed: 2001
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Additional Information:

Grey iron is an alloy of iron, carbon, and silicon, containing a higher percentage of the last two elements than found in malleable iron. The high strengths are obtained by the proper adjustment of the carbon and silicon contents or by alloying.

Cost estimates assume a conventional design under typical operating conditions. The costs do not include auxiliary equipment such as fans and ductwork. (EPA, 2000)

Costs are primarily based on volumetric flow rate and the amount of PM in the waste stream. In general, a small unit controlling a low pollutant levels will not be as cost effective as a large unit controlling a high pollutant levels. (EPA, 2000)

Pollutants requiring a high level of control or the fabric filters to be constructed of special materials will increase the costs of the system (EPA, 1998a). The additional costs for controlling complex waste streams are not included in the estimates. For these systems, the capital cost could increase by as much as 30% and the O&M cost could increase by as much as 7%.

In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Fabric filters may be in the form of sheets, cartridges, or bags, with many individual filter units together in a group. Bags are the most common type of filter. The dust cake that forms on the filter from the collected PM can significantly increase collection efficiency. (EPA, 2000)

Mechanical shaking is a popular cleaning method because it is both simple and effective. In typical operation, dusty gas enters an inlet pipe to the fabric filter and very large particles are removed using a baffle plate fall into the hopper. The gas stream is drawn from beneath a cell plate in the floor and into the filter bags (EPA, 2000). The gas proceeds from the inside to the outside of the filter bags. The particles collect on the inside of the bags, forming a filter cake. In mechanical shaking units, the tops of bags are attached to a shaker bar, moved briskly (usually in a horizontal direction) to clean the bags. The shaker bars are operated by mechanical motors or by hand (EPA, 1998b)..

Fabric filters are useful for collecting particles with resistivities either too low or too high for collection with electrostatic precipitators. Fabric filters are useful in controlling particulate matter less than or equal to 10 micrometers (µm) in diameter (PM₁₀) and particulate matter less than or equal to 2.5 µm in diameter (PM_{2.5}). Fabric filters may be good candidates for collecting fly ash from low-sulfur coals or containing high unburned carbon levels and are relatively difficult to collect with electrostatic precipitators. (EPA, 2000)

AT-A-GLANCE TABLE FOR POINT SOURCES

References:

EPA, 1998a: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, Chapter 5, EPA 453/B-96-001, Research Triangle Park, NC. December 1998.

EPA, 1998b: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

EPA, 2000: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Fabric Filter - Mechanical Shaker Cleaned Type," August 2000.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Ferrous Metals Processing - Gray Iron Foundries

Control Measure Name: Dry ESP-Wire Plate Type

Rule Name: Not Applicable

Pechan Measure Code: P2162

POD: 216

Application: This control is the use of dry electrostatic precipitators (ESP) to reduce PM emissions. An ESP uses electrical forces to move particles in an exhaust stream onto collector plates. Electrodes in the center of the flow are maintained at high voltage and generate an electrical field forcing particles to the collector walls. In dry ESPs, the collectors are knocked by various mechanical means to dislodge the particulate, which slides downward into a hopper.

This control applies to gray iron foundry operations.

Affected SCC:

30400301 Secondary Metal Production, Grey Iron Foundries, Cupola
30400302 Grey Iron Foundries, Reverberatory Furnace
30400303 Secondary Metal Production, Grey Iron Foundries, Electric Induction Furnace
30400304 Grey Iron Foundries, Electric Arc Furnace
30400305 Grey Iron Foundries, Annealing Operation
30400310 Secondary Metal Production, Grey Iron Foundries, Inoculation
30400315 Grey Iron Foundries, Charge Handling
30400318 Grey Iron Foundries, Pouring, Cooling
30400320 Secondary Metal Production, Grey Iron Foundries, Pouring/Casting
30400321 Grey Iron Foundries, Magnesium Treatment
30400322 Grey Iron Foundries, Refining
30400325 Grey Iron Foundries, Castings Cooling
30400331 Secondary Metal Production, Grey Iron Foundries, Casting Shakeout
30400333 Secondary Metal Production, Grey Iron Foundries, Shakeout Machine
30400340 Secondary Metal Production, Grey Iron Foundries, Grinding/Cleaning
30400341 Grey Iron Foundries, Casting Cleaning/Tumblers
30400350 Secondary Metal Production, Grey Iron Foundries, Sand Grinding/Handling
30400351 Secondary Metal Production, Grey Iron Foundries, Core Ovens
30400352 Secondary Metal Production, Grey Iron Foundries, Sand Grinding/Handling
30400353 Grey Iron Foundries, Core Ovens
30400357 Grey Iron Foundries, Conveyors/Elevators
30400358 Grey Iron Foundries, Sand Screens
30400360 Grey Iron Foundries, Castings Finishing
30400370 Grey Iron Foundries, Shell Core Machine
30400371 Grey Iron Foundries, Core Machines/Other
30400398 Grey Iron Foundries, Other Not Classified
30400399 Grey Iron Foundries, Other Not Classified

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: PM10 control efficiency is 98% from uncontrolled; PM2.5 control efficiency is 95% from uncontrolled

Equipment Life: 20 years

AT-A-GLANCE TABLE FOR POINT SOURCES

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs for ESPs of conventional design under typical operating conditions are developed using EPA cost estimating spreadsheets (EPA, 1996). When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan, 2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 1999). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$15 to \$50 per scfm
Typical value is \$27 per scfm

O&M Costs:

Range from \$4 to \$40 per scfm
Typical value is \$16 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for ESP (EPA, 1996). O&M costs were calculated for three model plants with flow rates of 200 and 500 thousand acfm and 1 million acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust loading of 6.0 grains per cubic feet. The operating time was assumed to be 8640 hours per year. The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.067	\$/kW-hr
Dust disposal	25	\$/ton disposed

Note: All costs are in 1995 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$40 to \$250 per

AT-A-GLANCE TABLE FOR POINT SOURCES

ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$110 per ton PM10 reduced. (1995\$)

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

Grey iron is an alloy of iron, carbon, and silicon, containing a higher percentage of the last two elements than found in malleable iron. The high strengths are obtained by the proper adjustment of the carbon and silicon contents or by alloying. Oil suppression can provide 75 to 99 percent control of TSP emissions. While the oil suppression system is favored because of costs, for the purpose of this study, fabric filters are being considered because they can achieve greater than 99 percent control of TSP as well as small and light particles.

In the wire-plate ESP, the gas flows around vertical, metal plates. The electrodes are long, weighted wires hanging between the plates. The voltage applied to the electrodes causes the gas between the electrodes to break down, known as a "corona." The electrodes are most often given a negative polarity because a negative corona supports a higher voltage than a positive corona.

Certain types of losses affect control efficiency. The dislodging of the accumulated layer also projects some of the particles back into the gas stream. These particles are processed in later sections of the ESP, but the particles from the last section have no chance to be recaptured. Due to the space needed at the top of the ESP for nonelectrified components, part of the stream may flow around the charged zones. This is called "sneakage" and places an upper limit on the collection efficiency of the ESP. Anti-sneakage baffles are used to force the sneakage flow to mix with the main gas stream for collection in later sections (EPA, 1998).

Another factor in the performance of ESPs is the resistivity of the collected material. All the ion current must pass through the collected layer to reach the ground plates. This creates an electric field in the layer, and it can become large enough to cause electrical breakdown. When this occurs, new ions of the wrong polarity are injected into the wire-plate gap reducing the charge on the particles, which may cause sparking. This condition is called "back corona." When this happens the collection ability of the unit is reduced. At low resistivities the particles are held on the plates so loosely that reentrainment levels are much higher. Hence, care must be taken in measuring or estimating resistivity because it is strongly affected by such variables as temperature, moisture, gas composition, particle composition, and surface characteristics (EPA, 1999).

Dusts with high resistivities are also not well-suited for collection in dry ESPs. These particles are not easily charged nor easily collected. High-resistivity particles form ash layers with very high voltage gradients on the collecting electrodes lead to back corona, reducing the charge on particles and lowering collection efficiency. Fly ash from the combustion of low-sulfur coal typically has a high resistivity, and thus is difficult to collect using dry ESPs (EPA, 1999).

References:

EPA, 1996: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, EPA 453/B-96-001, Research Triangle Park, NC. February 1996.

EPA, 1998: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

AT-A-GLANCE TABLE FOR POINT SOURCES

EPA, 1999: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Dry Electrostatic Precipitator (ESP) - Wire-Plate Type," May 1999.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Ferrous Metals Processing - Gray Iron Foundries

Control Measure Name: Fabric Filter (Reverse-Air Cleaned Type)

Rule Name: Not Applicable

Pechan Measure Code: P2163

POD: 216

Application: This control is the use of a reverse-air cleaned fabric filter to reduce PM emissions from waste streams. In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Reverse-air cleaning is performed by forcing clean air through the filters in the opposite direction of the dusty gas flow. The change in direction of the gas flow causes the bag to flex and crack the filter cake allowing for internal cake collection.

This control applies to gray iron foundry operations.

Affected SCC:

30400301 Secondary Metal Production, Grey Iron Foundries, Cupola
30400302 Grey Iron Foundries, Reverberatory Furnace
30400303 Secondary Metal Production, Grey Iron Foundries, Electric Induction Furnace
30400304 Grey Iron Foundries, Electric Arc Furnace
30400305 Grey Iron Foundries, Annealing Operation
30400310 Secondary Metal Production, Grey Iron Foundries, Inoculation
30400315 Grey Iron Foundries, Charge Handling
30400318 Grey Iron Foundries, Pouring, Cooling
30400320 Secondary Metal Production, Grey Iron Foundries, Pouring/Casting
30400321 Grey Iron Foundries, Magnesium Treatment
30400322 Grey Iron Foundries, Refining
30400325 Grey Iron Foundries, Castings Cooling
30400331 Secondary Metal Production, Grey Iron Foundries, Casting Shakeout
30400333 Secondary Metal Production, Grey Iron Foundries, Shakeout Machine
30400340 Secondary Metal Production, Grey Iron Foundries, Grinding/Cleaning
30400341 Grey Iron Foundries, Casting Cleaning/Tumblers
30400350 Secondary Metal Production, Grey Iron Foundries, Sand Grinding/Handling
30400351 Secondary Metal Production, Grey Iron Foundries, Core Ovens
30400352 Secondary Metal Production, Grey Iron Foundries, Sand Grinding/Handling
30400353 Grey Iron Foundries, Core Ovens
30400357 Grey Iron Foundries, Conveyors/Elevators
30400358 Grey Iron Foundries, Sand Screens
30400360 Grey Iron Foundries, Castings Finishing
30400370 Grey Iron Foundries, Shell Core Machine
30400371 Grey Iron Foundries, Core Machines/Other
30400398 Grey Iron Foundries, Other Not Classified
30400399 Grey Iron Foundries, Other Not Classified

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 99% from uncontrolled for both PM10 and PM2.5

Equipment Life: 20 years

AT-A-GLANCE TABLE FOR POINT SOURCES

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs for reverse-air cleaned systems are generated using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM₁₀ removed were used (Pechan,2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 2000). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$9 to \$84 per scfm
Typical value is \$34 per scfm

O&M Costs:

Range from \$6 to \$27 per scfm
Typical value is \$13 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). O&M costs were calculated for three model plants with flow rates of 25, 75 and 150 thousand acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust loading of 4.0 grains per cubic feet. The operating time was assumed to be 8760 hours per year. An average bag cost was estimated using the costs for standard bag types. Capital recovery for the periodic replacement of bags was included in the O&M cost of the bags using a bag life of 2 years (EPA, 1998a). The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.0671	\$/kW-hr
Compressed air	0.25	\$/1000 scf
Dust disposal	25	\$/ton disposed

AT-A-GLANCE TABLE FOR POINT SOURCES

Note: All costs are in 1998 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$53 to \$337 per ton PM₁₀ removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$148 per ton PM₁₀ reduced. (1998\$)

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

Grey iron is an alloy of iron, carbon, and silicon, containing a higher percentage of the last two elements than found in malleable iron. The high strengths are obtained by the proper adjustment of the carbon and silicon contents or by alloying.

The cost estimates assume a conventional design under typical operating conditions. The costs do not include any auxiliary equipment (EPA, 2000).

The capital cost for the reverse-jet cleaned fabric baghouse is based on information provided by a manufacturer (EPA, 2000). The capital cost includes only the purchased equipment cost.

Costs are primarily based on volumetric flow rate and the amount of PM in the waste stream. In general, a small unit controlling a low pollutant levels will not be as cost effective as a large unit controlling a high pollutant levels. (EPA, 2000)

Pollutants requiring a high level of control or the fabric filters to be constructed of special materials will increase the costs of the system (EPA, 1998a). The additional costs for controlling complex streams are not reflected in the estimates. For these systems, the capital cost could increase by as much as 40% and the O&M cost could increase by as much as 5%. (EPA, 2000)

In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Fabric filters may be in the form of sheets, cartridges, or bags, with many individual filter units together in a group. Bags are the most common type of filter. The dust cake that forms on the filter from the collected PM can significantly increase collection efficiency. (EPA, 2000)

Reverse-air cleaning is a popular filter cleaning method as it has been used extensively and improved over the years. It is a gentler but sometimes less effective clearing mechanism than mechanical shaking. Reverse-air cleaning is performed by forcing clean air through the filters in the opposite direction of the dusty gas flow. The change in direction of the gas flow causes the bag to flex and crack the filter cake allowing for internal cake collection (EPA, 2000).

The most common design is to have separate compartments within the fabric filter so that each can be isolated and cleaned separately while the others continue to treat the dusty gas. There are several methods of reversing the flow through the filters. One method of providing the reverse flow is by the use of a fan or cleaned gas from other compartments. Reverse-air cleaning only used alone in cases where the dust releases easily from the fabric. In many instances, reverse-air is used along with shaking, pulsing or sonic horns (EPA, 1998b).

Fabric filters are useful for collecting particles with resistivities either too low or too high for collection with electrostatic precipitators. Fabric filters are useful in controlling particulate matter less than or equal to 10 micrometers (µm) in diameter (PM₁₀) and particulate matter less than or equal to 2.5

AT-A-GLANCE TABLE FOR POINT SOURCES

µm in diameter (PM_{2.5}). Fabric filters may be good candidates for collecting fly ash from low-sulfur coals or containing high unburned carbon levels and are relatively difficult to collect with electrostatic precipitators. (EPA, 2000)

References:

EPA, 1998b: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

EPA, 1998a: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, Chapter 5, EPA 453/B-96-001, Research Triangle Park, NC. December 1998.

EPA, 2000: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Fabric Filter - Reverse-Air Cleaned Type," April 2000.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Ferrous Metals Processing - Gray Iron Foundries

Control Measure Name: Impingement-Plate Scrubber

Rule Name: Not Applicable

Pechan Measure Code: P2164

POD: 216

Application: This control is the use of an impingement-plate scrubber to reduce PM emissions. An impingement-plate scrubber is a vertical chamber with plates mounted horizontally inside a hollow shell. Impingement-plate scrubbers operate as countercurrent PM collection devices. The scrubbing liquid flows down the tower while the gas stream flows upward. Contact between the liquid and the particle-laden gas occurs on the plates. The plates are equipped with openings that allow the gas to pass through. Some plates are perforated or slotted, while more complex plates have valve-like openings (EPA, 1998).

This control applies to iron and steel production operations.

Affected SCC:

30400301 Secondary Metal Production, Grey Iron Foundries, Cupola
30400302 Grey Iron Foundries, Reverberatory Furnace
30400303 Secondary Metal Production, Grey Iron Foundries, Electric Induction Furnace
30400304 Grey Iron Foundries, Electric Arc Furnace
30400305 Grey Iron Foundries, Annealing Operation
30400310 Secondary Metal Production, Grey Iron Foundries, Inoculation
30400315 Grey Iron Foundries, Charge Handling
30400318 Grey Iron Foundries, Pouring, Cooling
30400320 Secondary Metal Production, Grey Iron Foundries, Pouring/Casting
30400321 Grey Iron Foundries, Magnesium Treatment
30400322 Grey Iron Foundries, Refining
30400325 Grey Iron Foundries, Castings Cooling
30400331 Secondary Metal Production, Grey Iron Foundries, Casting Shakeout
30400340 Secondary Metal Production, Grey Iron Foundries, Grinding/Cleaning
30400350 Secondary Metal Production, Grey Iron Foundries, Sand Grinding/Handling
30400351 Secondary Metal Production, Grey Iron Foundries, Core Ovens
30400352 Secondary Metal Production, Grey Iron Foundries, Sand Grinding/Handling
30400357 Grey Iron Foundries, Conveyors/Elevators
30400360 Grey Iron Foundries, Castings Finishing
30400370 Grey Iron Foundries, Shell Core Machine
30400371 Grey Iron Foundries, Core Machines/Other
30400398 Grey Iron Foundries, Other Not Classified
30400399 Grey Iron Foundries, Other Not Classified

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 64% from uncontrolled for both PM10 and PM2.5

Equipment Life: 10 years

Rule Effectiveness: 100%

Penetration: 100%

AT-A-GLANCE TABLE FOR POINT SOURCES

Cost Basis: The following are cost ranges for impingement-plate wet scrubbers of conventional design under typical operating conditions, developed using EPA cost-estimating spreadsheets (EPA, 1996) and referenced to the volumetric flow rate of the waste stream treated. When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM₁₀ removed were used (Pechan, 2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 1999). Total installed capital costs were annualized using a capital recovery factor, which is based on a 7 percent discount rate and the expected life of the control equipment (10 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$2 to \$11 per scfm
Typical value is \$7 per scfm

O&M Costs:

Range from \$3 to \$70 per scfm
Typical value is \$25 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for Impingement Plate Scrubbers (EPA, 1996). O&M costs were calculated for two model plants with flow rates of 1,000 and 100,000 acfm. The 1,000 acfm plant required 1 scrubber unit while the 100,000 acfm plant required 2 scrubber units. Both model plants were assumed to have 3 scrubber stages per scrubber unit. The average percentage of the total O&M cost was then calculated for each O&M cost component. The model plants were assumed to have a dust loading of 3.0 grains per cubic feet. The operating time was assumed to be 8760 hours per year. An inlet water flow rate for the scrubber was assumed to be 9.4 lbs/min. The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.067	\$/kW-hr
Process water price	0.20	\$/1000 gal
Dust disposal	25	\$/ton disposed
Wastewater treatment	3.8	\$/ thousand gal treated

AT-A-GLANCE TABLE FOR POINT SOURCES

Note: All costs are in 1995 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$46 to \$1,200 per ton PM₁₀ removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$431 per ton PM₁₀ reduced. (1995\$)

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

The cost estimates do not include costs for post-treatment or disposal of used solvent or waste. Actual costs can be substantially higher than in the ranges shown for applications which require expensive materials, solvents, or treatment methods. As a rule, smaller units controlling a low concentration waste stream will be much more expensive (per unit volumetric flow rate) than a large unit cleaning a high pollutant load flow (EPA, 1999).

In all types of impingement-plate scrubbers, the scrubbing liquid flows across each plate and down the inside of the tower onto the plate below. After the bottom plate, the liquid and collected PM flow out of the bottom of the tower. Impingement-plate scrubbers are usually designed to provide operator access to each tray, making them relatively easy to clean and maintain. Consequently, impingement-plate scrubbers are more suitable for PM collection than packed-bed scrubbers. Particles greater than 1 μ m in aerodynamic diameter can be collected effectively by impingement-plate scrubbers, but many particles <1 μ m in aerodynamic diameter will penetrate these devices (EPA, 1998).

The simplest impingement-plate scrubber is the sieve plate, which has round perforations (EPA, 1999). In this type of scrubber, the scrubbing liquid flows over the plates and the gas flows up through the holes. The gas velocity prevents the liquid from flowing down through the perforations. Gas-liquid-particle contact is achieved within the froth generated by the gas passing through the liquid layer. Complex plates, such as bubble cap or baffle plates, introduce an additional means of collecting PM. The bubble caps and baffles placed above the plate perforations force the gas to turn before escaping the layer of liquid. While the gas turns to avoid the obstacles, most PM cannot and is collected by impaction on the caps or baffles. Bubble caps and the like also prevent liquid from flowing down the perforations if the gas flow is reduced (EPA, 1998).

References:

EPA, 1996. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, EPA 453/B-96-001, Research Triangle Park, NC February 1996.

EPA, 1998. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC, October 1998.

EPA, 1999 U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Impingement-Plate/ Tray-Tower Scrubber," July 1999

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Ferrous Metals Processing - Gray Iron Foundries

Control Measure Name: Venturi Scrubber

Rule Name: Not Applicable

Pechan Measure Code: P2165

POD: 216

Application: The control is the use of a venturi scrubber to reduce PM emissions. A scrubber is a type of technology that removes air pollutants by inertial and diffusional interception. A venturi scrubber accelerates the waste gas stream to atomize the scrubbing liquid and to improve gas-liquid contact.

This control applies to iron and steel production operations.

Affected SCC:

30400301 Secondary Metal Production, Grey Iron Foundries, Cupola
30400302 Grey Iron Foundries, Reverberatory Furnace
30400303 Secondary Metal Production, Grey Iron Foundries, Electric Induction Furnace
30400304 Grey Iron Foundries, Electric Arc Furnace
30400305 Grey Iron Foundries, Annealing Operation
30400310 Secondary Metal Production, Grey Iron Foundries, Inoculation
30400315 Grey Iron Foundries, Charge Handling
30400318 Grey Iron Foundries, Pouring, Cooling
30400320 Secondary Metal Production, Grey Iron Foundries, Pouring/Casting
30400321 Grey Iron Foundries, Magnesium Treatment
30400322 Grey Iron Foundries, Refining
30400325 Grey Iron Foundries, Castings Cooling
30400331 Secondary Metal Production, Grey Iron Foundries, Casting Shakeout
30400340 Secondary Metal Production, Grey Iron Foundries, Grinding/Cleaning
30400350 Secondary Metal Production, Grey Iron Foundries, Sand Grinding/Handling
30400351 Secondary Metal Production, Grey Iron Foundries, Core Ovens
30400352 Secondary Metal Production, Grey Iron Foundries, Sand Grinding/Handling
30400353 Grey Iron Foundries, Core Ovens
30400357 Grey Iron Foundries, Conveyors/Elevators
30400358 Grey Iron Foundries, Sand Screens
30400360 Grey Iron Foundries, Castings Finishing
30400370 Grey Iron Foundries, Shell Core Machine
30400371 Grey Iron Foundries, Core Machines/Other
30400398 Grey Iron Foundries, Other Not Classified
30400399 Grey Iron Foundries, Other Not Classified

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 94% from uncontrolled for both PM10 and PM2.5

Equipment Life: 10 years

Rule Effectiveness: 100%

Penetration: 100%

AT-A-GLANCE TABLE FOR POINT SOURCES

Cost Basis: The following are cost ranges for venturi wet scrubbers, developed using EPA cost-estimating spreadsheets (EPA, 1996) and referenced to the volumetric flow rate of the waste stream treated. When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan, 2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 1999). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (10 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$3 to \$28 per scfm
Typical value is \$11 per scfm

O&M Costs:

Range from \$4 to \$119 per scfm
Typical value is \$42 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for Impingement Plate Scrubbers (EPA, 1996). O&M costs were calculated for two model plants with flow rates of 2,000 and 150,000 acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. The model plants were assumed to have a dust loading of 3.0 grains per cubic feet. The operating time was assumed to be 8760 hours per year. An inlet water flow rate for the scrubber was assumed to be 9.4 lbs/min. The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.067	\$/kW-hr
Process water price	0.20	\$/1000 gal
Dust disposal	25	\$/ton disposed
Wastewater treatment	3.8	\$/ thousand gal treated

Note: All costs are in 1995 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$76 to \$2,100

AT-A-GLANCE TABLE FOR POINT SOURCES

per ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$751 per ton PM10 reduced. (1995\$)

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

Grey iron is an alloy of iron, carbon, and silicon, containing a higher percentage of the last two elements than found in malleable iron. The high strengths are obtained by the proper adjustment of the carbon and silicon contents or by alloying. Oil suppression can provide 75 to 99 percent control of TSP emissions. While the oil suppression system is favored because of costs, for the purpose of this study, fabric filters are being considered because they can achieve greater than 99 percent control of TSP as well as small and light particles (EPA, 1999).

The costs do not include costs for post-treatment or disposal of used solvent or waste. Actual costs can be substantially higher than in the ranges shown for applications which require expensive materials, solvents, or treatment methods (EPA, 1999). As a rule, smaller units controlling a low concentration waste stream will be much more expensive (per unit volumetric flow rate) than a large unit cleaning a high pollutant load flow.

By product coke production is used to manufacture metallurgical coke by heating high-grade bituminous coal (low sulfur and low ash) in an enclosed oven chamber without oxygen. The resulting solid material consists of elemental carbon and any minerals (ash) that were present in the coal blend that did not volatilize during the process. Sources of air emissions consist of coke oven doors, coke oven lids and off-takes, coke oven charging, coke oven pushing, coke oven underfire stack, coke quenching, battery venting, and coke by-product-recovery plants.

A venturi scrubber accelerates the waste gas stream to improve gas-liquid contact. In a venturi scrubber, a "throat" section is built into the duct that forces the gas stream to accelerate (EPA, 1999). As the gas enters the venturi throat, both gas velocity and turbulence increase.

After the throat section, the mixture decelerates, and further impacts occur causing the droplets to agglomerate. Once the particles have been captured by the liquid, the wetted PM and excess liquid are separated from the gas stream through entrainment. This section usually consists of a cyclonic separator and/or a mist eliminator (EPA, 1998; Corbitt, 1990).

For PM applications, wet scrubbers generate waste, either a slurry or wet sludge. This creates the need for both wastewater treatment and solid waste disposal. Initially, the slurry is treated to separate the solid waste from the water (EPA, 1999). The treated water can then be reused or discharged. Once the water is removed, the remaining waste will be in the form of a solid or sludge. If the solid waste is inert and nontoxic, it can generally be land filled. Hazardous wastes will have more stringent procedures for disposal. In some cases, the solid waste may have value and can be sold or recycled (EPA, 1998).

References:

Corbitt, 1990: "Standard Handbook of Environmental Engineering," edited by Robert A. Corbitt, McGraw-Hill, New York, NY, 1990.

EPA, 1996: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, EPA 453/B-96-001, Research Triangle Park, NC February.

AT-A-GLANCE TABLE FOR POINT SOURCES

EPA, 1998: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

EPA, 1999: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Venturi Scrubber," July 1999.

Heumann, 1997: W. L. Heumann, "Industrial Air Pollution Control Systems," McGraw Hill Publishers, Inc., Washington, D.C., 1997.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

STAPPA/ALAPCO, 1996: State and Territorial Air Pollution Program Administrators and Association of Local Air Pollution Control Officials, "Controlling Particulate Matter Under the Clean Air Act: A Menu of Options," July 1996.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Ferrous Metals Processing - Gray Iron Foundries

Control Measure Name: Increased Monitoring Frequency (IMF) of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P3216

POD: 216

Application: This measure is to conduct improved monitoring for PM_{2.5} emissions at stationary sources. Improved monitoring in this case means increasing the monitoring frequency of electrostatic precipitators, scrubbers, and fabric filters from once per day to four times per hour, with no change in monitoring technique.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (Barr and Schaffner) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

304003** Secondary Metal Production, Grey Iron Foundries

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 6.5% for both PM₁₀ and PM_{2.5}

Equipment Life: Not applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs included the incremental record keeping and reporting associated with the increased monitoring frequency. Labor rates for 2003 were made that were obtained from the Bureau of Labor Statistics (labor rates include 140 percent overhead). The incremental costs included a one-time cost for development of the improved monitoring and recurring annual burden costs for incremental record keeping, reporting, and certification activities.

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$620 per ton PM reduced (2003\$).

Comments:

Status:

Last Reviewed: 2004

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM2.5 Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 2003.

BLS, 2003: Bureau of Labor Statistics, "Employer Costs for Employee Compensation – June 2003," Table 12, page 16, 2003.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Ferrous Metals Processing - Gray Iron Foundries

Control Measure Name: CEM Upgrade and Increased Monitoring Frequency of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P4216

POD: 216

Application: This measure examines the impacts of improving the PM monitoring technique at units currently using an ESP, scrubber, or fabric filter. In this improved technique scenario, the monitoring technique is upgraded to a PM continuous emission monitor. This improved monitoring technique also results in an increase to the monitoring frequency because a PM CEMS can make a measurement every 7.5 minutes. The monitoring frequency increases from once per day to eight times per hour.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (see References) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

304003** Secondary Metal Production, Grey Iron Foundries

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 7.7% for both PM10 and PM2.5

Equipment Life: Unknown

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The total capital and annual operating costs for implementing an improved monitoring technique are calculated based on data from the EPA CEMS Cost Model and the PM CEMS Knowledge document. Labor rates in the EPA CEMS Cost Model are scaled to reflect 2003 labor rates (including 140 percent overhead) provided by the Bureau of Labor Statistics.

The cost effectiveness at a percent excess emission rate of 0.46 percent is \$5,200 per ton of PM2.5. This is based on a \$34 million capital investment cost, and a \$14 million total annualized cost when applied to 128 facilities.

Note: All costs are in 2003 dollars.

AT-A-GLANCE TABLE FOR POINT SOURCES

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$5,200 per ton PM reduced (2003\$).

Comments:

Status:

Last Reviewed: 2004

Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM_{2.5} Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 8, 2003.

EPA CEMS Cost Model, Version 3.0, U.S. Environmental Protection Agency.

EPA, 2000: U.S. Environmental Protection Agency, "Current Knowledge of Particulate Matter (PM) Continuous Emissions Monitoring," Chapter 9, PM CEMS Cost, September 8, 2000.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Ferrous Metals Processing - Iron & Steel Production

Control Measure Name: Increased Monitoring Frequency (IMF) of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P3215

POD: 215

Application: This measure is to conduct improved monitoring for PM_{2.5} emissions at stationary sources. Improved monitoring in this case means increasing the monitoring frequency of electrostatic precipitators, scrubbers, and fabric filters from once per day to four times per hour, with no change in monitoring technique.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (Barr and Schaffner) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

303008** Primary Metal Production, Iron Production

303009** Primary Metal Production, Steel Manufacturing

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 6.5% for both PM₁₀ and PM_{2.5}

Equipment Life: Not applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs included the incremental record keeping and reporting associated with the increased monitoring frequency. Labor rates for 2003 were made that were obtained from the Bureau of Labor Statistics (labor rates include 140 percent overhead). The incremental costs included a one-time cost for development of the improved monitoring and recurring annual burden costs for incremental record keeping, reporting, and certification activities.

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$620 per ton PM reduced (2003\$).

Comments:

Status:

Last Reviewed: 2004

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM2.5 Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 2003.

BLS, 2003: Bureau of Labor Statistics, "Employer Costs for Employee Compensation – June 2003," Table 12, page 16, 2003.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Ferrous Metals Processing - Iron & Steel Production

Control Measure Name: CEM Upgrade and Increased Monitoring Frequency of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P4215

POD: 215

Application: This measure examines the impacts of improving the PM monitoring technique at units currently using an ESP, scrubber, or fabric filter. In this improved technique scenario, the monitoring technique is upgraded to a PM continuous emission monitor. This improved monitoring technique also results in an increase to the monitoring frequency because a PM CEMS can make a measurement every 7.5 minutes. The monitoring frequency increases from once per day to eight times per hour.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (see References) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

303008** Primary Metal Production, Iron Production

303009** Primary Metal Production, Steel Manufacturing

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 7.7% for both PM10 and PM2.5

Equipment Life: Unknown

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The total capital and annual operating costs for implementing an improved monitoring technique are calculated based on data from the EPA CEMS Cost Model and the PM CEMS Knowledge document. Labor rates in the EPA CEMS Cost Model are scaled to reflect 2003 labor rates (including 140 percent overhead) provided by the Bureau of Labor Statistics.

The cost effectiveness at a percent excess emission rate of 0.46 percent is \$5,200 per ton of PM2.5. This is based on a \$34 million capital investment cost, and a \$14 million total annualized cost when applied to 128 facilities.

Note: All costs are in 2003 dollars.

AT-A-GLANCE TABLE FOR POINT SOURCES

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$5,200 per ton PM reduced (2003\$).

Comments:

Status:

Last Reviewed: 2004

Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM_{2.5} Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 8, 2003.

EPA CEMS Cost Model, Version 3.0, U.S. Environmental Protection Agency.

EPA, 2000: U.S. Environmental Protection Agency, "Current Knowledge of Particulate Matter (PM) Continuous Emissions Monitoring," Chapter 9, PM CEMS Cost, September 8, 2000.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Ferrous Metals Processing - Iron and Steel Production

Control Measure Name: Fabric Filter (Pulse Jet Type)

Rule Name: Not Applicable

Pechan Measure Code: P2151

POD: 215

Application: This control is the addition of a pulse-jet cleaned fabric filter to reduce PM emissions from waste streams. In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Particulate-laden gas flows into the filter bag from the outside to the inside. The particles collected on the outside drop into a hopper below the fabric filter. During pulse-jet cleaning, a short burst of high pressure air is injected into the bags, dislodging the dust cake.

This control applies to iron and steel production operations.

Affected SCC:

30300801 Iron Production (See 3-03-015), Ore Charging
30300802 Iron Production (See 3-03-015), Agglomerate Charging
30300808 Primary Metal Production, Iron Production (See 3-03-015), Slag Crushing and Sizing
30300809 Iron Production (See 3-03-015), Slag Removal and Dumping
30300811 Iron Production (See 303015), Raw Mat'l Stockpiles, Coke Breeze, Limestone, Ore Fines
30300813 Iron Production (See 3-03-015), Windbox
30300814 Iron Production (See 3-03-015), Discharge End
30300817 Iron Production (See 3-03-015), Cooler
30300821 Iron Production (See 3-03-015), Unload Ore, Pellets, Limestone, into Blast Furnace
30300824 Iron Production (See 3-03-015), Blast Heating Stoves
30300825 Primary Metal Production, Iron Production (See 3-03-015), Cast House
30300826 Iron Production (See 3-03-015), Blast Furnace Slips
30300832 Iron Production (See 3-03-015), Unpaved Roads: Medium Duty Vehicles
30300833 Iron Production (See 3-03-015), Unpaved Roads: Heavy Duty Vehicles
30300834 Iron Production (See 3-03-015), Paved Roads: All Vehicle Types
30300841 Primary Metal Production, Iron Production (See 3-03-015), Flue Dust Unloading
30300842 Iron Production (See 3-03-015), Blended Ore Unloading
30300899 Iron Production (See 3-03-015), See Comment **
30300901 Primary Metal Production, Steel (See 303015), Open Hearth Furnace-Stack
30300904 Primary Metal Production, Steel (See 303015), Electric Arc Furnace-Alloy Steel (Stack)
30300906 Steel Manufacturing (See 3-03-015), Charging: Electric Arc Furnace
30300907 Steel Manufacturing (See 3-03-015), Tapping: Electric Arc Furnace
30300908 Primary Metal Prod., Steel (See 303015), Electric Arc Furnace-Carbon Steel (Stack)
30300910 Primary Metal Production, Steel Manufacturing (See 3-03-015), Pickling
30300911 Steel Manufacturing (See 3-03-015), Soaking Pits
30300912 Primary Metal Production, Steel Manufacturing (See 3-03-015), Grinding
30300913 Primary Metal Production, Steel (See 303015), Basic Oxygen Furnace-Open Hood-Stack
30300914 Steel Manufacturing (See 3-03-015), Basic Oxygen Furnace: Closed Hood-Stack
30300915 Steel Manufacturing (See 3-03-015), Hot Metal (Iron) Transfer to Steelmaking Furnace
30300916 Steel Manufacturing (See 3-03-015), Charging: BOF
30300917 Steel Manufacturing (See 3-03-015), Tapping: BOF
30300920 Steel Manufacturing (See 3-03-015), Hot Metal Desulfurization
30300921 Steel Manufacturing (See 3-03-015), Teeming (Unleaded Steel)
30300922 Primary Metal Production, Steel Manufacturing (See 3-03-015), Continuous Casting
30300923 Steel Manufacturing (See 3-03-015), Steel Furnace Slag Tapping and Dumping

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30300924 Steel Manufacturing (See 3-03-015), Steel Furnace Slag Processing
 30300931 Primary Metal Production, Steel Manufacturing (See 3-03-015), Hot Rolling
 30300932 Steel Manufacturing (See 3-03-015), Scarfing
 30300933 Primary Metal Production, Steel Manufacturing (See 3-03-015), Reheat Furnaces
 30300934 Primary Metal Production, Steel (See 303015), Heat Treating Furnaces-Annealing
 30300935 Primary Metal Production, Steel Manufacturing (See 3-03-015), Cold Rolling
 30300936 Primary Metal Production, Steel Manufacturing (See 3-03-015), Coating: Tin, Zinc, etc.
 30300998 Steel Manufacturing (See 3-03-015), Other Not Classified
 30300999 Primary Metal Production, Steel Manufacturing (See 3-03-015), Other Not Classified

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 99% from uncontrolled for both PM10 and PM2.5

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs for pulse-jet cleaned systems are generated using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan, 2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 2000). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$6 to \$26 per scfm
 Typical value is \$13 per scfm

O&M Costs:

Range from \$5 to \$24 per scfm

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Typical value is \$11 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). O&M costs were calculated for three model plants with flow rates of 25, 75 and 150 thousand acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust loading of 4.0 grains per cubic feet. The operating time was assumed to be 8760 hours per year. An average bag cost was estimated using the costs for standard bag types. Capital recovery for the periodic replacement of bags was included in the O&M cost of the bags using a bag life of 2 years (EPA, 1998a). The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.0671	\$/kW-hr
Compressed air	0.25	\$/1000 scf
Dust disposal	25	\$/ton disposed

Note: All costs are in 1998 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$42 to \$266 per ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$117 per ton PM10 reduced. (1998\$)

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

Steel normally is produced in either basic oxygen process furnaces or electric arc furnaces. In the basic oxygen process furnace, a mixture of 70 percent molten iron from the blast furnace and 30 percent iron scrap are melted together. Pure oxygen is blown across the top or through the molten steel to oxidize carbon and oxygen impurities, thus removing these from the steel. Basic oxygen process furnaces are large open-mouthed furnaces that can be tilted to accept a charge or to tap the molten steel to a charging ladle for transfer to an ingot mold or continuous caster.

Because basic oxygen furnaces are open, they produce significant uncontrolled particulate emissions, notably during the refining stage when oxygen is being blown. Electric arc furnaces use the current passing between carbon electrodes to heat molten steel, but also use oxy-fuel burners to accelerate the initial melting process. These furnaces are charged largely with scrap iron. Significant emissions occur during charging, when the furnace roof is open, during melting, as the electrodes are lowered into the scrap and the arc is struck, and during tapping, when alloying elements are added to the melt.

The cost estimates assume a conventional design under typical operating conditions and do not include auxiliary equipment such as fans and ductwork. The costs for pulse-jet cleaned systems are generated using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a).

Costs are primarily based on volumetric flow rate and the amount of PM in the waste stream. In general, a small unit controlling a low pollutant levels will not be as cost effective as a large unit controlling a high pollutant levels. (EPA, 2000)

Pollutants requiring a high level of control or the fabric filters to be constructed of special materials

AT-A-GLANCE TABLE FOR POINT SOURCES

will increase the costs of the system (EPA, 1998a). The additional costs for controlling complex waste streams are not included in the estimates. For these systems, the capital cost could increase by as much as 75% and the operational and maintenance (O&M) cost could increase by as much as 20% (EPA, 2000).

In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Fabric filters may be in the form of sheets, cartridges, or bags, with many individual filter units together in a group. Bags are the most common type of filter. The dust cake that forms on the filter from the collected PM can significantly increase collection efficiency. (EPA, 2000)

Pulse-jet cleaning of fabric filters is a relatively new type of fabric filter, as they have only been used for the past 30 years. This cleaning mechanism has grown in popularity because it can treat high dust loadings, operate at constant pressure drop, and occupy less space than other types of fabric filters (EPA, 2000). Particulate-laden gas flows into the bag. The gas flows from the outside to the inside of the bags, and then out the gas exhaust. The particles collected on the outside drop into a hopper below the fabric filter (EPA, 1998b).

During pulse-jet cleaning, a short burst of high pressure air is injected into the bags (EPA, 1998b). The pulse is blown through a venturi nozzle at the top of the bags and establishes a shock wave that continues onto the bottom of the bag. The wave flexes the fabric dislodging the dust cake.

There are several unique attributes of pulse-jet cleaning. The cleaning pulse is very brief allowing the flow of dusty gas to continue during cleaning. The bags not being cleaned continue to filter, taking on extra duty from the bags being cleaned (EPA, 2000). Pulse-jet cleaning is more intense and occurs with greater frequency than the other fabric filter cleaning methods. The cleaning dislodges nearly all of the dust cake each time the bag is pulsed. Pulse-jet filters, as a result, do not rely on a dust cake to provide filtration. Felted (non-woven) fabrics are used in these types of filters because they do not require a dust cake. Also it has been found that woven fabrics used with pulse-jet cleaning leak dust after they are cleaned (EPA, 1998b).

Since bags cleaned by the pulse-jet method do not need to be isolated for cleaning, pulsejet cleaned fabric filters do not need extra compartments to maintain adequate filtration during cleaning. Also, because of the intense and frequent nature of the cleaning, they can treat higher gas flow rates with higher dust loadings. Consequently, fabric filters cleaned by the pulse-jet method can be smaller than other filters in the treatment of the same amount of gas and dust, making higher gas-to-cloth ratios achievable (EPA, 1998b).

Fabric filters are useful for collecting particles with resistivities either too low or too high for collection with electrostatic precipitators. Fabric filters are useful in controlling particulate matter less than or equal to 10 micrometers (μm) in diameter (PM₁₀) and particulate matter less than or equal to 2.5 μm in diameter (PM_{2.5}). Fabric filters may be good candidates for collecting fly ash from low-sulfur coals or containing high unburned carbon levels and are relatively difficult to collect with electrostatic precipitators. (EPA, 2000)

References:

EPA, 1998a: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, Chapter 5, EPA 453/B-96-001, Research Triangle Park, NC. December 1998.

EPA, 1998b: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001,

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Research Triangle Park, NC., October 1998.

EPA, 2000: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Fabric Filter - Pulse-Jet Cleaned Type," April 2000.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Ferrous Metals Processing - Iron and Steel Production

Control Measure Name: Fabric Filter (Mech. Shaker Type)

Rule Name: Not Applicable

Pechan Measure Code: P2152

POD: 215

Application: This control is the addition of a mechanical shaker type fabric filter to reduce PM emissions. In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. The gas stream is drawn from beneath a cell plate in the floor and into the filter bags. The gas proceeds from the inside to the outside of the filter bags. The particles collect on the inside of the bags, forming a filter cake. In mechanical shaking units, the tops of bags are attached to a shaker bar, moved briskly to clean the bags.

This control applies to iron and steel production operations.

Affected SCC:

30300801 Iron Production (See 3-03-015), Ore Charging
30300802 Iron Production (See 3-03-015), Agglomerate Charging
30300808 Primary Metal Production, Iron Production (See 3-03-015), Slag Crushing and Sizing
30300809 Iron Production (See 3-03-015), Slag Removal and Dumping
30300811 Iron Production (See 303015), Raw Mat'l Stockpiles, Coke Breeze, Limestone, Ore Fines
30300813 Iron Production (See 3-03-015), Windbox
30300814 Iron Production (See 3-03-015), Discharge End
30300817 Iron Production (See 3-03-015), Cooler
30300821 Iron Production (See 3-03-015), Unload Ore, Pellets, Limestone, into Blast Furnace
30300824 Iron Production (See 3-03-015), Blast Heating Stoves
30300825 Primary Metal Production, Iron Production (See 3-03-015), Cast House
30300826 Iron Production (See 3-03-015), Blast Furnace Slips
30300832 Iron Production (See 3-03-015), Unpaved Roads: Medium Duty Vehicles
30300833 Iron Production (See 3-03-015), Unpaved Roads: Heavy Duty Vehicles
30300834 Iron Production (See 3-03-015), Paved Roads: All Vehicle Types
30300841 Primary Metal Production, Iron Production (See 3-03-015), Flue Dust Unloading
30300842 Iron Production (See 3-03-015), Blended Ore Unloading
30300899 Iron Production (See 3-03-015), See Comment **
30300901 Primary Metal Production, Steel (See 303015), Open Hearth Furnace-Stack
30300904 Primary Metal Production, Steel (See 303015), Electric Arc Furnace-Alloy Steel (Stack)
30300906 Steel Manufacturing (See 3-03-015), Charging: Electric Arc Furnace
30300907 Steel Manufacturing (See 3-03-015), Tapping: Electric Arc Furnace
30300908 Primary Metal Prod., Steel (See 303015), Electric Arc Furnace-Carbon Steel (Stack)
30300910 Primary Metal Production, Steel Manufacturing (See 3-03-015), Pickling
30300911 Steel Manufacturing (See 3-03-015), Soaking Pits
30300912 Primary Metal Production, Steel Manufacturing (See 3-03-015), Grinding
30300913 Primary Metal Production, Steel (See 303015), Basic Oxygen Furnace-Open Hood-Stack
30300914 Steel Manufacturing (See 3-03-015), Basic Oxygen Furnace: Closed Hood-Stack
30300915 Steel Manufacturing (See 3-03-015), Hot Metal (Iron) Transfer to Steelmaking Furnace
30300916 Steel Manufacturing (See 3-03-015), Charging: BOF
30300917 Steel Manufacturing (See 3-03-015), Tapping: BOF
30300920 Steel Manufacturing (See 3-03-015), Hot Metal Desulfurization
30300921 Steel Manufacturing (See 3-03-015), Teeming (Unleaded Steel)
30300922 Primary Metal Production, Steel Manufacturing (See 3-03-015), Continuous Casting

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30300923 Steel Manufacturing (See 3-03-015), Steel Furnace Slag Tapping and Dumping
 30300924 Steel Manufacturing (See 3-03-015), Steel Furnace Slag Processing
 30300931 Primary Metal Production, Steel Manufacturing (See 3-03-015), Hot Rolling
 30300932 Steel Manufacturing (See 3-03-015), Scarfing
 30300933 Primary Metal Production, Steel Manufacturing (See 3-03-015), Reheat Furnaces
 30300934 Primary Metal Production, Steel (See 303015), Heat Treating Furnaces-Annealing
 30300935 Primary Metal Production, Steel Manufacturing (See 3-03-015), Cold Rolling
 30300936 Primary Metal Production, Steel Manufacturing (See 3-03-015), Coating: Tin, Zinc, etc.
 30300998 Steel Manufacturing (See 3-03-015), Other Not Classified
 30300999 Primary Metal Production, Steel Manufacturing (See 3-03-015), Other Not Classified

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 99% from uncontrolled for both PM10 and PM2.5

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs for mechanical shaker cleaned systems are generated using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan, 2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 2000). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$8 to \$71 per scfm
 Typical value is \$29 per scfm

O&M Costs:

AT-A-GLANCE TABLE FOR POINT SOURCES

Range from \$4 to \$24 per scfm
Typical value is \$11 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). O&M costs were calculated for three model plants with flow rates of 25, 75 and 150 thousand acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust loading of 4.0 grains per cubic feet. The operating time was assumed to be 8760 hours per year. An average bag cost was estimated using the costs for standard bag types. Capital recovery for the periodic replacement of bags was included in the O&M cost of the bags using a bag life of 2 years (EPA, 1998a). The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.0671	\$/kW-hr
Compressed air	0.25	\$/1000 scf
Dust disposal	25	\$/ton disposed

Note: All costs are in 1998 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$37 to \$303 per ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$126 per ton PM10 reduced. (1998\$)

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

Steel normally is produced in either basic oxygen process furnaces or electric arc furnaces. In the basic oxygen process furnace, a mixture of 70 percent molten iron from the blast furnace and 30 percent iron scrap are melted together. Pure oxygen is blown across the top or through the molten steel to oxidize carbon and oxygen impurities, thus removing these from the steel. Basic oxygen process furnaces are large open-mouthed furnaces that can be tilted to accept a charge or to tap the molten steel to a charging ladle for transfer to an ingot mold or continuous caster.

Because basic oxygen furnaces are open, they produce significant uncontrolled particulate emissions, notably during the refining stage when oxygen is being blown. Electric arc furnaces use the current passing between carbon electrodes to heat molten steel, but also use oxy-fuel burners to accelerate the initial melting process. These furnaces are charged largely with scrap iron. Significant emissions occur during charging, when the furnace roof is open, during melting, as the electrodes are lowered into the scrap and the arc is struck, and during tapping, when alloying elements are added to the melt.

Cost estimates assume a conventional design under typical operating conditions. The costs do not include auxiliary equipment such as fans and ductwork. (EPA, 2000)

Costs are primarily based on volumetric flow rate and the amount of PM in the waste stream. In general, a small unit controlling a low pollutant levels will not be as cost effective as a large unit controlling a high pollutant levels. (EPA, 2000)

Pollutants requiring a high level of control or the fabric filters to be constructed of special materials

AT-A-GLANCE TABLE FOR POINT SOURCES

will increase the costs of the system (EPA, 1998a). The additional costs for controlling complex waste streams are not included in the estimates. For these systems, the capital cost could increase by as much as 30% and the O&M cost could increase by as much as 7%.

In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Fabric filters may be in the form of sheets, cartridges, or bags, with many individual filter units together in a group. Bags are the most common type of filter. The dust cake that forms on the filter from the collected PM can significantly increase collection efficiency. (EPA, 2000)

Mechanical shaking is a popular cleaning method because it is both simple and effective. In typical operation, dusty gas enters an inlet pipe to the fabric filter and very large particles are removed using a baffle plate fall into the hopper. The gas stream is drawn from beneath a cell plate in the floor and into the filter bags (EPA, 2000). The gas proceeds from the inside to the outside of the filter bags. The particles collect on the inside of the bags, forming a filter cake. In mechanical shaking units, the tops of bags are attached to a shaker bar, moved briskly (usually in a horizontal direction) to clean the bags. The shaker bars are operated by mechanical motors or by hand (EPA, 1998b)..

Fabric filters are useful for collecting particles with resistivities either too low or too high for collection with electrostatic precipitators. Fabric filters are useful in controlling particulate matter less than or equal to 10 micrometers (μm) in diameter (PM₁₀) and particulate matter less than or equal to 2.5 μm in diameter (PM_{2.5}). Fabric filters may be good candidates for collecting fly ash from low-sulfur coals or containing high unburned carbon levels and are relatively difficult to collect with electrostatic precipitators. (EPA, 2000)

References:

EPA, 1998a: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, Chapter 5, EPA 453/B-96-001, Research Triangle Park, NC. December 1998.

EPA, 1998b: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

EPA, 2000: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Fabric Filter - Mechanical Shaker Cleaned Type," August 2000.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Ferrous Metals Processing - Iron and Steel Production

Control Measure Name: Dry ESP-Wire Plate Type

Rule Name: Not Applicable

Pechan Measure Code: P2153

POD: 215

Application: This control is the use of dry electrostatic precipitators (ESP) to reduce PM emissions. An ESP uses electrical forces to move particles in an exhaust stream onto collector plates. Electrodes in the center of the flow are maintained at high voltage and generate an electrical field forcing particles to the collector walls. In dry ESPs, the collectors are knocked by various mechanical means to dislodge the particulate, which slides downward into a hopper.

This control applies to iron and steel production operations.

Affected SCC:

30300801 Iron Production (See 3-03-015), Ore Charging
30300802 Iron Production (See 3-03-015), Agglomerate Charging
30300808 Primary Metal Production, Iron Production (See 3-03-015), Slag Crushing and Sizing
30300809 Iron Production (See 3-03-015), Slag Removal and Dumping
30300811 Iron Production (See 303015), Raw Mat'l Stockpiles, Coke Breeze, Limestone, Ore Fines
30300813 Iron Production (See 3-03-015), Windbox
30300814 Iron Production (See 3-03-015), Discharge End
30300817 Iron Production (See 3-03-015), Cooler
30300821 Iron Production (See 3-03-015), Unload Ore, Pellets, Limestone, into Blast Furnace
30300824 Iron Production (See 3-03-015), Blast Heating Stoves
30300825 Primary Metal Production, Iron Production (See 3-03-015), Cast House
30300826 Iron Production (See 3-03-015), Blast Furnace Slips
30300832 Iron Production (See 3-03-015), Unpaved Roads: Medium Duty Vehicles
30300833 Iron Production (See 3-03-015), Unpaved Roads: Heavy Duty Vehicles
30300834 Iron Production (See 3-03-015), Paved Roads: All Vehicle Types
30300841 Primary Metal Production, Iron Production (See 3-03-015), Flue Dust Unloading
30300842 Iron Production (See 3-03-015), Blended Ore Unloading
30300899 Iron Production (See 3-03-015), See Comment **
30300901 Primary Metal Production, Steel (See 303015), Open Hearth Furnace-Stack
30300904 Primary Metal Production, Steel (See 303015), Electric Arc Furnace-Alloy Steel (Stack)
30300906 Steel Manufacturing (See 3-03-015), Charging: Electric Arc Furnace
30300907 Steel Manufacturing (See 3-03-015), Tapping: Electric Arc Furnace
30300908 Primary Metal Prod., Steel (See 303015), Electric Arc Furnace-Carbon Steel (Stack)
30300910 Primary Metal Production, Steel Manufacturing (See 3-03-015), Pickling
30300911 Steel Manufacturing (See 3-03-015), Soaking Pits
30300912 Primary Metal Production, Steel Manufacturing (See 3-03-015), Grinding
30300913 Primary Metal Production, Steel (See 303015), Basic Oxygen Furnace-Open Hood-Stack
30300914 Steel Manufacturing (See 3-03-015), Basic Oxygen Furnace: Closed Hood-Stack
30300915 Steel Manufacturing (See 3-03-015), Hot Metal (Iron) Transfer to Steelmaking Furnace
30300916 Steel Manufacturing (See 3-03-015), Charging: BOF
30300917 Steel Manufacturing (See 3-03-015), Tapping: BOF
30300920 Steel Manufacturing (See 3-03-015), Hot Metal Desulfurization
30300921 Steel Manufacturing (See 3-03-015), Teeming (Unleaded Steel)
30300922 Primary Metal Production, Steel Manufacturing (See 3-03-015), Continuous Casting
30300923 Steel Manufacturing (See 3-03-015), Steel Furnace Slag Tapping and Dumping

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30300924 Steel Manufacturing (See 3-03-015), Steel Furnace Slag Processing
 30300931 Primary Metal Production, Steel Manufacturing (See 3-03-015), Hot Rolling
 30300932 Steel Manufacturing (See 3-03-015), Scarfing
 30300933 Primary Metal Production, Steel Manufacturing (See 3-03-015), Reheat Furnaces
 30300934 Primary Metal Production, Steel (See 303015), Heat Treating Furnaces-Annealing
 30300935 Primary Metal Production, Steel Manufacturing (See 3-03-015), Cold Rolling
 30300936 Primary Metal Production, Steel Manufacturing (See 3-03-015), Coating: Tin, Zinc, etc.
 30300998 Steel Manufacturing (See 3-03-015), Other Not Classified
 30300999 Primary Metal Production, Steel Manufacturing (See 3-03-015), Other Not Classified

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: PM10 control efficiency is 98% from uncontrolled; PM2.5 control efficiency is 95% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs for ESPs of conventional design under typical operating conditions are developed using EPA cost estimating spreadsheets (EPA, 1996). When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan, 2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 1999). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$15 to \$50 per scfm
 Typical value is \$27 per scfm

O&M Costs:

AT-A-GLANCE TABLE FOR POINT SOURCES

Range from \$4 to \$40 per scfm
Typical value is \$16 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for ESP (EPA, 1996). O&M costs were calculated for three model plants with flow rates of 200 and 500 thousand acfm and 1 million acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust loading of 6.0 grains per cubic feet. The operating time was assumed to be 8640 hours per year. The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.067	\$/kW-hr
Dust disposal	25	\$/ton disposed

Note: All costs are in 1995 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$40 to \$250 per ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$110 per ton PM10 reduced. (1995\$)

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

Steel normally is produced in either basic oxygen process furnaces or electric arc furnaces. In the basic oxygen process furnace, a mixture of 70 percent molten iron from the blast furnace and 30 percent iron scrap are melted together. Pure oxygen is blown across the top or through the molten steel to oxidize carbon and oxygen impurities, thus removing these from the steel. Basic oxygen process furnaces are large open-mouthed furnaces that can be tilted to accept a charge or to tap the molten steel to a charging ladle for transfer to an ingot mold or continuous caster.

Because basic oxygen furnaces are open, they produce significant uncontrolled particulate emissions, notably during the refining stage when oxygen is being blown. Electric arc furnaces use the current passing between carbon electrodes to heat molten steel, but also use oxy-fuel burners to accelerate the initial melting process. These furnaces are charged largely with scrap iron. Significant emissions occur during charging, when the furnace roof is open, during melting, as the electrodes are lowered into the scrap and the arc is struck, and during tapping, when alloying elements are added to the melt.

In the wire-plate ESP, the gas flows around vertical, metal plates. The electrodes are long, weighted wires hanging between the plates. The voltage applied to the electrodes causes the gas between the electrodes to break down, known as a "corona." The electrodes are most often given a negative polarity because a negative corona supports a higher voltage than a positive corona.

Certain types of losses affect control efficiency. The dislodging of the accumulated layer also projects some of the particles back into the gas stream. These particles are processed in later sections of the ESP, but the particles from the last section have no chance to be recaptured. Due to the space needed at the top of the ESP for nonelectrified components, part of the stream may flow around the charged zones. This is called "sneakage" and places an upper limit on the collection efficiency of the ESP. Anti-sneakage baffles are used to force the sneakage flow to mix with the

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main gas stream for collection in later sections (EPA, 1998).

Another factor in the performance of ESPs is the resistivity of the collected material. All the ion current must pass through the collected layer to reach the ground plates. This creates an electric field in the layer, and it can become large enough to cause electrical breakdown. When this occurs, new ions of the wrong polarity are injected into the wire-plate gap reducing the charge on the particles, which may cause sparking. This condition is called "back corona." When this happens the collection ability of the unit is reduced. At low resistivities the particles are held on the plates so loosely that reentrainment levels are much higher. Hence, care must be taken in measuring or estimating resistivity because it is strongly affected by such variables as temperature, moisture, gas composition, particle composition, and surface characteristics (EPA, 1999).

Dusts with high resistivities are also not well-suited for collection in dry ESPs. These particles are not easily charged nor easily collected. High-resistivity particles form ash layers with very high voltage gradients on the collecting electrodes lead to back corona, reducing the charge on particles and lowering collection efficiency. Fly ash from the combustion of low-sulfur coal typically has a high resistivity, and thus is difficult to collect using dry ESPs (EPA, 1999).

References:

EPA, 1996: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, EPA 453/B-96-001, Research Triangle Park, NC. February 1996.

EPA, 1998: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

EPA, 1999: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Dry Electrostatic Precipitator (ESP) - Wire-Plate Type," May 1999.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Ferrous Metals Processing - Iron and Steel Production

Control Measure Name: Wet ESP - Wire Plate Type

Rule Name: Not Applicable

Pechan Measure Code: P2154

POD: 215

Application: This control is the use of a wire-plate type electrostatic precipitator (ESP) to reduce PM emissions. An ESP uses electrical forces to move particles in an exhaust stream onto collector plates. Electrodes in the center of the flow are maintained at high voltage and generate an electrical field forcing particles to the collector walls. Wet ESPs use a stream of water, in place of rapping mechanisms, to dislodge particulate from the plates and into a sump.

This control applies to iron and steel production operations.

Affected SCC:

30300801 Iron Production (See 3-03-015), Ore Charging
30300802 Iron Production (See 3-03-015), Agglomerate Charging
30300808 Primary Metal Production, Iron Production (See 3-03-015), Slag Crushing and Sizing
30300809 Iron Production (See 3-03-015), Slag Removal and Dumping
30300811 Iron Production (See 303015), Raw Mat'l Stockpiles, Coke Breeze, Limestone, Ore Fines
30300813 Iron Production (See 3-03-015), Windbox
30300814 Iron Production (See 3-03-015), Discharge End
30300817 Iron Production (See 3-03-015), Cooler
30300821 Iron Production (See 3-03-015), Unload Ore, Pellets, Limestone, into Blast Furnace
30300824 Iron Production (See 3-03-015), Blast Heating Stoves
30300825 Primary Metal Production, Iron Production (See 3-03-015), Cast House
30300826 Iron Production (See 3-03-015), Blast Furnace Slips
30300832 Iron Production (See 3-03-015), Unpaved Roads: Medium Duty Vehicles
30300833 Iron Production (See 3-03-015), Unpaved Roads: Heavy Duty Vehicles
30300834 Iron Production (See 3-03-015), Paved Roads: All Vehicle Types
30300841 Primary Metal Production, Iron Production (See 3-03-015), Flue Dust Unloading
30300842 Iron Production (See 3-03-015), Blended Ore Unloading
30300899 Iron Production (See 3-03-015), See Comment **
30300901 Primary Metal Production, Steel (See 303015), Open Hearth Furnace-Stack
30300904 Primary Metal Production, Steel (See 303015), Electric Arc Furnace-Alloy Steel (Stack)
30300906 Steel Manufacturing (See 3-03-015), Charging: Electric Arc Furnace
30300907 Steel Manufacturing (See 3-03-015), Tapping: Electric Arc Furnace
30300908 Primary Metal Prod., Steel (See 303015), Electric Arc Furnace-Carbon Steel (Stack)
30300910 Primary Metal Production, Steel Manufacturing (See 3-03-015), Pickling
30300911 Steel Manufacturing (See 3-03-015), Soaking Pits
30300912 Primary Metal Production, Steel Manufacturing (See 3-03-015), Grinding
30300913 Primary Metal Production, Steel (See 303015), Basic Oxygen Furnace-Open Hood-Stack
30300914 Steel Manufacturing (See 3-03-015), Basic Oxygen Furnace: Closed Hood-Stack
30300915 Steel Manufacturing (See 3-03-015), Hot Metal (Iron) Transfer to Steelmaking Furnace
30300916 Steel Manufacturing (See 3-03-015), Charging: BOF
30300917 Steel Manufacturing (See 3-03-015), Tapping: BOF
30300920 Steel Manufacturing (See 3-03-015), Hot Metal Desulfurization
30300921 Steel Manufacturing (See 3-03-015), Teeming (Unleaded Steel)
30300922 Primary Metal Production, Steel Manufacturing (See 3-03-015), Continuous Casting
30300923 Steel Manufacturing (See 3-03-015), Steel Furnace Slag Tapping and Dumping

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30300924 Steel Manufacturing (See 3-03-015), Steel Furnace Slag Processing
 30300931 Primary Metal Production, Steel Manufacturing (See 3-03-015), Hot Rolling
 30300932 Steel Manufacturing (See 3-03-015), Scarfing
 30300933 Primary Metal Production, Steel Manufacturing (See 3-03-015), Reheat Furnaces
 30300934 Primary Metal Production, Steel (See 303015), Heat Treating Furnaces-Annealing
 30300935 Primary Metal Production, Steel Manufacturing (See 3-03-015), Cold Rolling
 30300936 Primary Metal Production, Steel Manufacturing (See 3-03-015), Coating: Tin, Zinc, etc.
 30300998 Steel Manufacturing (See 3-03-015), Other Not Classified
 30300999 Primary Metal Production, Steel Manufacturing (See 3-03-015), Other Not Classified

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: PM10 control efficiency is 99% from uncontrolled; PM2.5 control efficiency is 95% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The following are cost ranges for wire-plate ESPs, developed using EPA cost-estimating spreadsheets for dry wire-plate ESPs with adjustments made to reflect wet wire-plate ESPs (EPA, 1999). Capital and operating costs are generally higher due to noncorrosive materials requirements, increased water usage, and treatment and disposal of wet effluent. When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan, 2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 1990). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$30 to \$60 per scfm
 Typical value is \$40 per scfm

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O&M Costs:

Range from \$6 to \$45 per scfm
Typical value is \$19 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for ESP (EPA, 1999). O&M costs were calculated for three model plants with flow rates of 10, 15 and 20 thousand acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust loading of 6.0 grains per cubic feet. The operating time was assumed to be 8640 hours per year. A water flow rate for the ESP was assumed to be 5 gal/min per thousand acfm. The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.067	\$/kW-hr
Process water price	0.20	\$/1000 gal
Dust disposal	20	\$/ton disposed
Wastewater treatment	1.5	\$/ thousand gal treated

Note: All costs are in 1995 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$55 to \$550 per ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$220 per ton PM10 reduced. (1995\$)

Comments:

Status: Demonstrated	Last Reviewed: 2001
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Additional Information:

Steel normally is produced in either basic oxygen process furnaces or electric arc furnaces. In the basic oxygen process furnace, a mixture of 70 percent molten iron from the blast furnace and 30 percent iron scrap are melted together. Pure oxygen is blown across the top or through the molten steel to oxidize carbon and oxygen impurities, thus removing these from the steel. Basic oxygen process furnaces are large open-mouthed furnaces that can be tilted to accept a charge or to tap the molten steel to a charging ladle for transfer to an ingot mold or continuous caster.

Because basic oxygen furnaces are open, they produce significant uncontrolled particulate emissions, notably during the refining stage when oxygen is being blown. Electric arc furnaces use the current passing between carbon electrodes to heat molten steel, but also use oxy-fuel burners to accelerate the initial melting process. These furnaces are charged largely with scrap iron. Significant emissions occur during charging, when the furnace roof is open, during melting, as the electrodes are lowered into the scrap and the arc is struck, and during tapping, when alloying elements are added to the melt.

Costs can be substantially higher than in the ranges shown for pollutants which require an unusually high level of control, or which require the ESP to be constructed of special materials such as titanium (EPA, 1999). In most cases, smaller units controlling a low concentration waste stream will not be as cost effective as a large unit cleaning a high pollutant load flow (EPA, 1998).

In the wire-plate ESP, the gas flows around vertical, metal plates. The electrodes are long, weighted

AT-A-GLANCE TABLE FOR POINT SOURCES

wires hanging between the plates. The voltage applied to the electrodes causes the gas between the electrodes to break down, known as a "corona." The electrodes are most often given a negative polarity because a negative corona supports a higher voltage than a positive corona.

Certain types of losses affect control efficiency. The dislodging of the accumulated layer also projects some of the particles back into the gas stream. These particles are processed in later sections of the ESP, but the particles from the last section have no chance to be recaptured. Due to the space needed at the top of the ESP for nonelectrified components, part of the stream may flow around the charged zones. This is called "sneakage" and places an upper limit on the collection efficiency of the ESP. Anti-sneakage baffles are used to force the sneakage flow to mix with the main gas stream for collection in later sections (EPA, 1998).

Wire-Plate Type Wet ESPs require a source of wash water near the top of the collector plates. This wash system replaces the rapping mechanism used by dry ESPs. The water flows with the collected particles into a sump from which the fluid is pumped or drained. A portion of the fluid may be recycled to reduce the total amount of water required. The remainder is pumped into a settling pond or passed through a dewatering stage, with subsequent disposal of the sludge (AWMA, 1992).

Unlike dry ESPs, resistivity of the collected material is not a major factor in performance. Because of the high humidity in a wet ESP, the resistivity of particles is lowered, eliminating the "back corona" condition. The frequent washing of the plates also limits particle buildup on the collectors (EPA, 1998).

For wet ESPs, the handling wastewaters must be considered (EPA, 1999). For simple systems with innocuous dusts, water with particles collected by the ESP may be discharged from the ESP system to a solids-removing clarifier. More complicated systems may require skimming and sludge removal, clarification in dedicated equipment, pH adjustment, and/or treatment to remove dissolved solids. Recirculation of treated water to the ESP may approach 100 percent (AWMA, 1992).

References:

AWMA, 1992: Air & Waste Management Association, Air Pollution Engineering Manual, Van Nostrand Reinhold, New York.

EPA, 1996: U.S. EPA, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, EPA 453/B-96-001, Research Triangle Park, NC. February.

EPA, 1998: U.S. EPA, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October.

EPA, 1999: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Wet Electrostatic Precipitator (ESP) - Wire-Plate Type," May 1999

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Ferrous Metals Processing - Iron and Steel Production

Control Measure Name: Fabric Filter (Reverse-Air Cleaned Type)

Rule Name: Not Applicable

Pechan Measure Code: P2155

POD: 215

Application: This control is the use of a reverse-air cleaned fabric filter to reduce PM emissions from waste streams. In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Reverse-air cleaning is performed by forcing clean air through the filters in the opposite direction of the dusty gas flow. The change in direction of the gas flow causes the bag to flex and crack the filter cake allowing for internal cake collection.

This control applies to iron and steel production operations.

Affected SCC:

30300801 Iron Production (See 3-03-015), Ore Charging
30300802 Iron Production (See 3-03-015), Agglomerate Charging
30300808 Primary Metal Production, Iron Production (See 3-03-015), Slag Crushing and Sizing
30300809 Iron Production (See 3-03-015), Slag Removal and Dumping
30300811 Iron Production (See 303015), Raw Mat'l Stockpiles, Coke Breeze, Limestone, Ore Fines
30300813 Iron Production (See 3-03-015), Windbox
30300814 Iron Production (See 3-03-015), Discharge End
30300817 Iron Production (See 3-03-015), Cooler
30300821 Iron Production (See 3-03-015), Unload Ore, Pellets, Limestone, into Blast Furnace
30300824 Iron Production (See 3-03-015), Blast Heating Stoves
30300825 Primary Metal Production, Iron Production (See 3-03-015), Cast House
30300826 Iron Production (See 3-03-015), Blast Furnace Slips
30300832 Iron Production (See 3-03-015), Unpaved Roads: Medium Duty Vehicles
30300833 Iron Production (See 3-03-015), Unpaved Roads: Heavy Duty Vehicles
30300834 Iron Production (See 3-03-015), Paved Roads: All Vehicle Types
30300841 Primary Metal Production, Iron Production (See 3-03-015), Flue Dust Unloading
30300842 Iron Production (See 3-03-015), Blended Ore Unloading
30300899 Iron Production (See 3-03-015), See Comment **
30300901 Primary Metal Production, Steel (See 303015), Open Hearth Furnace-Stack
30300904 Primary Metal Production, Steel (See 303015), Electric Arc Furnace-Alloy Steel (Stack)
30300906 Steel Manufacturing (See 3-03-015), Charging: Electric Arc Furnace
30300907 Steel Manufacturing (See 3-03-015), Tapping: Electric Arc Furnace
30300908 Primary Metal Prod., Steel (See 303015), Electric Arc Furnace-Carbon Steel (Stack)
30300910 Primary Metal Production, Steel Manufacturing (See 3-03-015), Pickling
30300911 Steel Manufacturing (See 3-03-015), Soaking Pits
30300912 Primary Metal Production, Steel Manufacturing (See 3-03-015), Grinding
30300913 Primary Metal Production, Steel (See 303015), Basic Oxygen Furnace-Open Hood-Stack
30300914 Steel Manufacturing (See 3-03-015), Basic Oxygen Furnace: Closed Hood-Stack
30300915 Steel Manufacturing (See 3-03-015), Hot Metal (Iron) Transfer to Steelmaking Furnace
30300916 Steel Manufacturing (See 3-03-015), Charging: BOF
30300917 Steel Manufacturing (See 3-03-015), Tapping: BOF
30300920 Steel Manufacturing (See 3-03-015), Hot Metal Desulfurization
30300921 Steel Manufacturing (See 3-03-015), Teeming (Unleaded Steel)
30300922 Primary Metal Production, Steel Manufacturing (See 3-03-015), Continuous Casting
30300923 Steel Manufacturing (See 3-03-015), Steel Furnace Slag Tapping and Dumping

AT-A-GLANCE TABLE FOR POINT SOURCES

30300924 Steel Manufacturing (See 3-03-015), Steel Furnace Slag Processing
 30300931 Primary Metal Production, Steel Manufacturing (See 3-03-015), Hot Rolling
 30300932 Steel Manufacturing (See 3-03-015), Scarfing
 30300933 Primary Metal Production, Steel Manufacturing (See 3-03-015), Reheat Furnaces
 30300934 Primary Metal Production, Steel (See 303015), Heat Treating Furnaces-Annealing
 30300935 Primary Metal Production, Steel Manufacturing (See 3-03-015), Cold Rolling
 30300936 Primary Metal Production, Steel Manufacturing (See 3-03-015), Coating: Tin, Zinc, etc.
 30300998 Steel Manufacturing (See 3-03-015), Other Not Classified
 30300999 Primary Metal Production, Steel Manufacturing (See 3-03-015), Other Not Classified

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 99% from uncontrolled for both PM10 and PM2.5

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs for reverse-air cleaned systems are generated using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan, 2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 2000). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$9 to \$84 per scfm
 Typical value is \$34 per scfm

O&M Costs:

Range from \$6 to \$27 per scfm

AT-A-GLANCE TABLE FOR POINT SOURCES

Typical value is \$13 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). O&M costs were calculated for three model plants with flow rates of 25, 75 and 150 thousand acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust loading of 4.0 grains per cubic feet. The operating time was assumed to be 8760 hours per year. An average bag cost was estimated using the costs for standard bag types. Capital recovery for the periodic replacement of bags was included in the O&M cost of the bags using a bag life of 2 years (EPA, 1998a). The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.0671	\$/kW-hr
Compressed air	0.25	\$/1000 scf
Dust disposal	25	\$/ton disposed

Note: All costs are in 1998 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$53 to \$337 per ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$148 per ton PM10 reduced. (1998\$)

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

Steel normally is produced in either basic oxygen process furnaces or electric arc furnaces. In the basic oxygen process furnace, a mixture of 70 percent molten iron from the blast furnace and 30 percent iron scrap are melted together. Pure oxygen is blown across the top or through the molten steel to oxidize carbon and oxygen impurities, thus removing these from the steel. Basic oxygen process furnaces are large open-mouthed furnaces that can be tilted to accept a charge or to tap the molten steel to a charging ladle for transfer to an ingot mold or continuous caster.

Because basic oxygen furnaces are open, they produce significant uncontrolled particulate emissions, notably during the refining stage when oxygen is being blown. Electric arc furnaces use the current passing between carbon electrodes to heat molten steel, but also use oxy-fuel burners to accelerate the initial melting process. These furnaces are charged largely with scrap iron. Significant emissions occur during charging, when the furnace roof is open, during melting, as the electrodes are lowered into the scrap and the arc is struck, and during tapping, when alloying elements are added to the melt.

The cost estimates assume a conventional design under typical operating conditions. The costs do not include any auxiliary equipment (EPA, 2000).

The capital cost for the reverse-jet cleaned fabric baghouse is based on information provided by a manufacturer (EPA, 2000). The capital cost includes only the purchased equipment cost.

Costs are primarily based on volumetric flow rate and the amount of PM in the waste stream. In general, a small unit controlling a low pollutant levels will not be as cost effective as a large unit controlling a high pollutant levels. (EPA, 2000)

AT-A-GLANCE TABLE FOR POINT SOURCES

Pollutants requiring a high level of control or the fabric filters to be constructed of special materials will increase the costs of the system (EPA, 1998a). The additional costs for controlling complex streams are not reflected in the estimates. For these systems, the capital cost could increase by as much as 40% and the O&M cost could increase by as much as 5%. (EPA, 2000)

In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Fabric filters may be in the form of sheets, cartridges, or bags, with many individual filter units together in a group. Bags are the most common type of filter. The dust cake that forms on the filter from the collected PM can significantly increase collection efficiency. (EPA, 2000)

Reverse-air cleaning is a popular filter cleaning method as it has been used extensively and improved over the years. It is a gentler but sometimes less effective clearing mechanism than mechanical shaking. Reverse-air cleaning is performed by forcing clean air through the filters in the opposite direction of the dusty gas flow. The change in direction of the gas flow causes the bag to flex and crack the filter cake allowing for internal cake collection (EPA, 2000).

The most common design is to have separate compartments within the fabric filter so that each can be isolated and cleaned separately while the others continue to treat the dusty gas. There are several methods of reversing the flow through the filters. One method of providing the reverse flow is by the use of a fan or cleaned gas from other compartments. Reverse-air cleaning only used alone in cases where the dust releases easily from the fabric. In many instances, reverse-air is used along with shaking, pulsing or sonic horns (EPA, 1998b).

Fabric filters are useful for collecting particles with resistivities either too low or too high for collection with electrostatic precipitators. Fabric filters are useful in controlling particulate matter less than or equal to 10 micrometers (μm) in diameter (PM₁₀) and particulate matter less than or equal to 2.5 μm in diameter (PM_{2.5}). Fabric filters may be good candidates for collecting fly ash from low-sulfur coals or containing high unburned carbon levels and are relatively difficult to collect with electrostatic precipitators. (EPA, 2000)

References:

EPA, 1998b: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

EPA, 1998a: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, Chapter 5, EPA 453/B-96-001, Research Triangle Park, NC. December 1998.

EPA, 2000: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Fabric Filter - Reverse-Air Cleaned Type," April 2000.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Ferrous Metals Processing - Iron and Steel Production

Control Measure Name: Venturi Scrubber

Rule Name: Not Applicable

Pechan Measure Code: P2156

POD: 215

Application: The control is the use of a venturi scrubber to reduce PM emissions. A scrubber is a type of technology that removes air pollutants by inertial and diffusional interception. A venturi scrubber accelerates the waste gas stream to atomize the scrubbing liquid and to improve gas-liquid contact.

This control applies to iron and steel processing and production operations.

Affected SCC:

30300801 Iron Production (See 3-03-015), Ore Charging
30300808 Primary Metal Production, Iron Production (See 3-03-015), Slag Crushing and Sizing
30300809 Iron Production (See 3-03-015), Slag Removal and Dumping
30300811 Iron Production (See 303015), Raw Mat'l Stockpiles, Coke Breeze, Limestone, Ore Fines
30300813 Iron Production (See 3-03-015), Windbox
30300817 Iron Production (See 3-03-015), Cooler
30300821 Iron Production (See 3-03-015), Unload Ore, Pellets, Limestone, into Blast Furnace
30300824 Iron Production (See 3-03-015), Blast Heating Stoves
30300825 Primary Metal Production, Iron Production (See 3-03-015), Cast House
30300826 Iron Production (See 3-03-015), Blast Furnace Slips
30300832 Iron Production (See 3-03-015), Unpaved Roads: Medium Duty Vehicles
30300833 Iron Production (See 3-03-015), Unpaved Roads: Heavy Duty Vehicles
30300834 Iron Production (See 3-03-015), Paved Roads: All Vehicle Types
30300841 Primary Metal Production, Iron Production (See 3-03-015), Flue Dust Unloading
30300842 Iron Production (See 3-03-015), Blended Ore Unloading
30300899 Iron Production (See 3-03-015), See Comment **
30300904 Primary Metal Production, Steel (See 303015), Electric Arc Furnace Alloy Steel (Stack)
30300906 Steel Manufacturing (See 3-03-015), Charging: Electric Arc Furnace
30300907 Steel Manufacturing (See 3-03-015), Tapping: Electric Arc Furnace
30300908 Primary Metal Prod., Steel (See 303015), Electric Arc Furnace-Carbon Steel (Stack)
30300910 Primary Metal Production, Steel Manufacturing (See 3-03-015), Pickling
30300911 Steel Manufacturing (See 3-03-015), Soaking Pits
30300912 Primary Metal Production, Steel Manufacturing (See 3-03-015), Grinding
30300913 Primary Metal Production, Steel (See 303015), Basic Oxygen Furnace-Open Hood-Stack
30300914 Steel Manufacturing (See 3-03-015), Basic Oxygen Furnace: Closed Hood-Stack
30300916 Steel Manufacturing (See 3-03-015), Charging: BOF
30300917 Steel Manufacturing (See 3-03-015), Tapping: BOF
30300920 Steel Manufacturing (See 3-03-015), Hot Metal Desulfurization
30300921 Steel Manufacturing (See 3-03-015), Teeming (Unleaded Steel)
30300922 Primary Metal Production, Steel Manufacturing (See 3-03-015), Continuous Casting
30300923 Steel Manufacturing (See 3-03-015), Steel Furnace Slag Tapping and Dumping
30300924 Steel Manufacturing (See 3-03-015), Steel Furnace Slag Processing
30300931 Primary Metal Production, Steel Manufacturing (See 3-03-015), Hot Rolling
30300932 Steel Manufacturing (See 3-03-015), Scarfing
30300933 Primary Metal Production, Steel Manufacturing (See 3-03-015), Reheat Furnaces
30300934 Primary Metal Production, Steel (See 303015), Heat Treating Furnaces-Annealing
30300935 Primary Metal Production, Steel Manufacturing (See 3-03-015), Cold Rolling

AT-A-GLANCE TABLE FOR POINT SOURCES

30300936 Primary Metal Production, Steel Manufacturing (See 3-03-015), Coating: Tin, Zinc, etc.
 30300998 Steel Manufacturing (See 3-03-015), Other Not Classified
 30300999 Primary Metal Production, Steel Manufacturing (See 3-03-015), Other Not Classified

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: PM10 control efficiency is 73% from uncontrolled; PM2.5 control efficiency is 25% from uncontrolled

Equipment Life: 10 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The following are cost ranges for venturi wet scrubbers, developed using EPA cost-estimating spreadsheets (EPA, 1996) and referenced to the volumetric flow rate of the waste stream treated. When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan, 2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 1999). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (10 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$3 to \$28 per scfm
 Typical value is \$11 per scfm

O&M Costs:

Range from \$4 to \$119 per scfm
 Typical value is \$42 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for Impingement Plate

AT-A-GLANCE TABLE FOR POINT SOURCES

Scrubbers (EPA, 1996). O&M costs were calculated for two model plants with flow rates of 2,000 and 150,000 acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. The model plants were assumed to have a dust loading of 3.0 grains per cubic feet. The operating time was assumed to be 8760 hours per year. An inlet water flow rate for the scrubber was assumed to be 9.4 lbs/min. The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.067	\$/kW-hr
Process water price	0.20	\$/1000 gal
Dust disposal	25	\$/ton disposed
Wastewater treatment	3.8	\$/ thousand gal treated

Note: All costs are in 1995 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$76 to \$2,100 per ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$751 per ton PM10 reduced. (1995\$)

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

Steel normally is produced in either basic oxygen process furnaces or electric arc furnaces. In the basic oxygen process furnace, a mixture of 70 percent molten iron from the blast furnace and 30 percent iron scrap are melted together. Pure oxygen is blown across the top or through the molten steel to oxidize carbon and oxygen impurities, thus removing these from the steel. Basic oxygen process furnaces are large open-mouthed furnaces that can be tilted to accept a charge or to tap the molten steel to a charging ladle for transfer to an ingot mold or continuous caster.

Because basic oxygen furnaces are open, they produce significant uncontrolled particulate emissions, notably during the refining stage when oxygen is being blown. Electric arc furnaces use the current passing between carbon electrodes to heat molten steel, but also use oxy-fuel burners to accelerate the initial melting process. These furnaces are charged largely with scrap iron. Significant emissions occur during charging, when the furnace roof is open, during melting, as the electrodes are lowered into the scrap and the arc is struck, and during tapping, when alloying elements are added to the melt.

The costs do not include costs for post-treatment or disposal of used solvent or waste. Actual costs can be substantially higher than in the ranges shown for applications which require expensive materials, solvents, or treatment methods (EPA, 1999). As a rule, smaller units controlling a low concentration waste stream will be much more expensive (per unit volumetric flow rate) than a large unit cleaning a high pollutant load flow.

By product coke production is used to manufacture metallurgical coke by heating high-grade bituminous coal (low sulfur and low ash) in an enclosed oven chamber without oxygen. The resulting solid material consists of elemental carbon and any minerals (ash) that were present in the coal blend that did not volatilize during the process. Sources of air emissions consist of coke oven doors, coke oven lids and off-takes, coke oven charging, coke oven pushing, coke oven underfire stack, coke quenching, battery venting, and coke by-product-recovery plants.

A venturi scrubber accelerates the waste gas stream to improve gas-liquid contact. In a venturi

AT-A-GLANCE TABLE FOR POINT SOURCES

scrubber, a "throat" section is built into the duct that forces the gas stream to accelerate (EPA, 1999). As the gas enters the venturi throat, both gas velocity and turbulence increase.

After the throat section, the mixture decelerates, and further impacts occur causing the droplets to agglomerate. Once the particles have been captured by the liquid, the wetted PM and excess liquid are separated from the gas stream through entrainment. This section usually consists of a cyclonic separator and/or a mist eliminator (EPA, 1998; Corbitt, 1990).

For PM applications, wet scrubbers generate waste, either a slurry or wet sludge. This creates the need for both wastewater treatment and solid waste disposal. Initially, the slurry is treated to separate the solid waste from the water (EPA, 1999). The treated water can then be reused or discharged. Once the water is removed, the remaining waste will be in the form of a solid or sludge. If the solid waste is inert and nontoxic, it can generally be land filled. Hazardous wastes will have more stringent procedures for disposal. In some cases, the solid waste may have value and can be sold or recycled (EPA, 1998).

References:

Corbitt, 1990: "Standard Handbook of Environmental Engineering," edited by Robert A. Corbitt, McGraw-Hill, New York, NY, 1990.

EPA, 1996: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, EPA 453/B-96-001, Research Triangle Park, NC February.

EPA, 1998: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

EPA, 1999: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Venturi Scrubber," July 1999.

Heumann, 1997: W. L. Heumann, "Industrial Air Pollution Control Systems," McGraw Hill Publishers, Inc., Washington, D.C., 1997.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

STAPPA/ALAPCO, 1996: State and Territorial Air Pollution Program Administrators and Association of Local Air Pollution Control Officials, "Controlling Particulate Matter Under the Clean Air Act: A Menu of Options," July 1996.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Ferrous Metals Processing - Other

Control Measure Name: Increased Monitoring Frequency (IMF) of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P3240

POD: 240

Application: This measure is to conduct improved monitoring for PM_{2.5} emissions at stationary sources. Improved monitoring in this case means increasing the monitoring frequency of electrostatic precipitators, scrubbers, and fabric filters from once per day to four times per hour, with no change in monitoring technique.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (Barr and Schaffner) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

303015** Primary Metal Production, Integrated Iron and Steel Manufacturing

303024** Primary Metal Production, Metal Mining (General Processes)

303023** Primary Metal Production, Zinc Production

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 6.5% for both PM₁₀ and PM_{2.5}

Equipment Life: Not applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs included the incremental record keeping and reporting associated with the increased monitoring frequency. Labor rates for 2003 were made that were obtained from the Bureau of Labor Statistics (labor rates include 140 percent overhead). The incremental costs included a one-time cost for development of the improved monitoring and recurring annual burden costs for incremental record keeping, reporting, and certification activities.

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$620 per ton PM reduced (2003\$).

Comments:

Status:

Last Reviewed: 2004

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM2.5 Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 2003.

BLS, 2003: Bureau of Labor Statistics, "Employer Costs for Employee Compensation – June 2003," Table 12, page 16, 2003.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Ferrous Metals Processing - Other

Control Measure Name: CEM Upgrade and Increased Monitoring Frequency of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P4240

POD: 240

Application: This measure examines the impacts of improving the PM monitoring technique at units currently using an ESP, scrubber, or fabric filter. In this improved technique scenario, the monitoring technique is upgraded to a PM continuous emission monitor. This improved monitoring technique also results in an increase to the monitoring frequency because a PM CEMS can make a measurement every 7.5 minutes. The monitoring frequency increases from once per day to eight times per hour.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (see References) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

303015** Primary Metal Production, Integrated Iron and Steel Manufacturing

303024** Primary Metal Production, Metal Mining (General Processes)

303023** Primary Metal Production, Zinc Production

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 7.7% for both PM10 and PM2.5

Equipment Life: Unknown

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The total capital and annual operating costs for implementing an improved monitoring technique are calculated based on data from the EPA CEMS Cost Model and the PM CEMS Knowledge document. Labor rates in the EPA CEMS Cost Model are scaled to reflect 2003 labor rates (including 140 percent overhead) provided by the Bureau of Labor Statistics.

The cost effectiveness at a percent excess emission rate of 0.46 percent is \$5,200 per ton of PM2.5. This is based on a \$34 million capital investment cost, and a \$14 million total annualized cost when applied to 128 facilities.

AT-A-GLANCE TABLE FOR POINT SOURCES

Note: All costs are in 2003 dollars.

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$5,200 per ton PM reduced (2003\$).

Comments:

Status:

Last Reviewed: 2004

Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM_{2.5} Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 8, 2003.

EPA CEMS Cost Model, Version 3.0, U.S. Environmental Protection Agency.

EPA, 2000: U.S. Environmental Protection Agency, "Current Knowledge of Particulate Matter (PM) Continuous Emissions Monitoring," Chapter 9, PM CEMS Cost, September 8, 2000.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Ferrous Metals Processing - Steel Foundries

Control Measure Name: Fabric Filter (Pulse Jet Type)

Rule Name: Not Applicable

Pechan Measure Code: P2171

POD: 217

Application: This control is the addition of a pulse-jet cleaned fabric filter to reduce PM emissions from waste streams. In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Particulate-laden gas flows into the filter bag from the outside to the inside. The particles collected on the outside drop into a hopper below the fabric filter. During pulse-jet cleaning, a short burst of high pressure air is injected into the bags, dislodging the dust cake.

This control applies to ferrous metals processing operations, specifically steel foundries.

Affected SCC:

30400701 Secondary Metal Production, Steel Foundries, Electric Arc Furnace
30400704 Steel Foundries, Heat Treating Furnace
30400705 Steel Foundries, Electric Induction Furnace
30400706 Steel Foundries, Sand Grinding/Handling
30400708 Steel Foundries, Pouring/Casting
30400709 Steel Foundries, Casting Shakeout
30400711 Steel Foundries, Cleaning
30400712 Steel Foundries, Charge Handling
30400713 Steel Foundries, Castings Cooling
30400714 Steel Foundries, Shakeout Machine
30400715 Steel Foundries, Finishing
30400716 Secondary Metal Production, Steel Foundries, Sand Grinding/Handling
30400717 Steel Foundries, Core Ovens
30400724 Steel Foundries, Sand Screens
30400799 Steel Foundries, Other Not Classified
30400999 Malleable Iron, Other Not Classified

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 99% from uncontrolled for both PM10 and PM2.5

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs for pulse-jet cleaned systems are generated using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan,2001).

AT-A-GLANCE TABLE FOR POINT SOURCES

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 2000). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$6 to \$26 per scfm
Typical value is \$13 per scfm

O&M Costs:

Range from \$5 to \$24 per scfm
Typical value is \$11 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). O&M costs were calculated for three model plants with flow rates of 25, 75 and 150 thousand acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust loading of 4.0 grains per cubic feet. The operating time was assumed to be 8760 hours per year. An average bag cost was estimated using the costs for standard bag types. Capital recovery for the periodic replacement of bags was included in the O&M cost of the bags using a bag life of 2 years (EPA, 1998a). The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.0671	\$/kW-hr
Compressed air	0.25	\$/1000 scf
Dust disposal	25	\$/ton disposed

Note: All costs are in 1998 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$42 to \$266 per ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$117 per ton PM10 reduced. (1998\$)

Comments:

Status: Demonstrated

Last Reviewed: 2001

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

The cost estimates assume a conventional design under typical operating conditions and do not include auxiliary equipment such as fans and ductwork. The costs for pulse-jet cleaned systems are generated using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a).

Costs are primarily based on volumetric flow rate and the amount of PM in the waste stream. In general, a small unit controlling a low pollutant levels will not be as cost effective as a large unit controlling a high pollutant levels. (EPA, 2000)

Pollutants requiring a high level of control or the fabric filters to be constructed of special materials will increase the costs of the system (EPA, 1998a). The additional costs for controlling complex waste streams are not included in the estimates. For these systems, the capital cost could increase by as much as 75% and the operational and maintenance (O&M) cost could increase by as much as 20% (EPA, 2000).

In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Fabric filters may be in the form of sheets, cartridges, or bags, with many individual filter units together in a group. Bags are the most common type of filter. The dust cake that forms on the filter from the collected PM can significantly increase collection efficiency. (EPA, 2000)

Pulse-jet cleaning of fabric filters is a relatively new type of fabric filter, as they have only been used for the past 30 years. This cleaning mechanism has grown in popularity because it can treat high dust loadings, operate at constant pressure drop, and occupy less space than other types of fabric filters (EPA, 2000). Particulate-laden gas flows into the bag. The gas flows from the outside to the inside of the bags, and then out the gas exhaust. The particles collected on the outside drop into a hopper below the fabric filter (EPA, 1998b).

During pulse-jet cleaning, a short burst of high pressure air is injected into the bags (EPA, 1998b). The pulse is blown through a venturi nozzle at the top of the bags and establishes a shock wave that continues onto the bottom of the bag. The wave flexes the fabric dislodging the dust cake.

There are several unique attributes of pulse-jet cleaning. The cleaning pulse is very brief allowing the flow of dusty gas to continue during cleaning. The bags not being cleaned continue to filter, taking on extra duty from the bags being cleaned (EPA, 2000). Pulse-jet cleaning is more intense and occurs with greater frequency than the other fabric filter cleaning methods. The cleaning dislodges nearly all of the dust cake each time the bag is pulsed. Pulse-jet filters, as a result, do not rely on a dust cake to provide filtration. Felted (non-woven) fabrics are used in these types of filters because they do not require a dust cake. Also it has been found that woven fabrics used with pulse-jet cleaning leak dust after they are cleaned (EPA, 1998b).

Since bags cleaned by the pulse-jet method do not need to be isolated for cleaning, pulsejet cleaned fabric filters do not need extra compartments to maintain adequate filtration during cleaning. Also, because of the intense and frequent nature of the cleaning, they can treat higher gas flow rates with higher dust loadings. Consequently, fabric filters cleaned by the pulse-jet method can be smaller than other filters in the treatment of the same amount of gas and dust, making higher gas-to-cloth ratios achievable (EPA, 1998b).

Fabric filters are useful for collecting particles with resistivities either too low or too high for collection with electrostatic precipitators. Fabric filters are useful in controlling particulate matter less than or equal to 10 micrometers (μm) in diameter (PM10) and particulate matter less than or equal to 2.5 μm in diameter (PM2.5). Fabric filters may be good candidates for collecting fly ash from low-sulfur

AT-A-GLANCE TABLE FOR POINT SOURCES

coals or containing high unburned carbon levels and are relatively difficult to collect with electrostatic precipitators. (EPA, 2000)

References:

EPA, 1998a: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, Chapter 5, EPA 453/B-96-001, Research Triangle Park, NC. December 1998.

EPA, 1998b: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

EPA, 2000: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Fabric Filter - Pulse-Jet Cleaned Type," April 2000.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Ferrous Metals Processing - Steel Foundries

Control Measure Name: Fabric Filter (Mech. Shaker Type)

Rule Name: Not Applicable

Pechan Measure Code: P2172

POD: 217

Application: This control is the addition of a mechanical shaker type fabric filter to reduce PM emissions. In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. The gas stream is drawn from beneath a cell plate in the floor and into the filter bags. The gas proceeds from the inside to the outside of the filter bags. The particles collect on the inside of the bags, forming a filter cake. In mechanical shaking units, the tops of bags are attached to a shaker bar, moved briskly to clean the bags.

This control applies to ferrous metals processing operations, specifically steel foundries.

Affected SCC:

30400701 Secondary Metal Production, Steel Foundries, Electric Arc Furnace
30400704 Steel Foundries, Heat Treating Furnace
30400705 Steel Foundries, Electric Induction Furnace
30400706 Steel Foundries, Sand Grinding/Handling
30400708 Steel Foundries, Pouring/Casting
30400709 Steel Foundries, Casting Shakeout
30400711 Steel Foundries, Cleaning
30400712 Steel Foundries, Charge Handling
30400713 Steel Foundries, Castings Cooling
30400714 Steel Foundries, Shakeout Machine
30400715 Steel Foundries, Finishing
30400716 Secondary Metal Production, Steel Foundries, Sand Grinding/Handling
30400717 Steel Foundries, Core Ovens
30400724 Steel Foundries, Sand Screens
30400799 Steel Foundries, Other Not Classified
30400999 Malleable Iron, Other Not Classified

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 99% from uncontrolled for both PM10 and PM2.5

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs for mechanical shaker cleaned systems are generated using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan,2001).

AT-A-GLANCE TABLE FOR POINT SOURCES

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 2000). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$8 to \$71 per scfm
Typical value is \$29 per scfm

O&M Costs:

Range from \$4 to \$24 per scfm
Typical value is \$11 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). O&M costs were calculated for three model plants with flow rates of 25, 75 and 150 thousand acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust loading of 4.0 grains per cubic feet. The operating time was assumed to be 8760 hours per year. An average bag cost was estimated using the costs for standard bag types. Capital recovery for the periodic replacement of bags was included in the O&M cost of the bags using a bag life of 2 years (EPA, 1998a). The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.0671	\$/kW-hr
Compressed air	0.25	\$/1000 scf
Dust disposal	25	\$/ton disposed

Note: All costs are in 1998 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$37 to \$303 per ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$126 per ton PM10 reduced. (1998\$)

Comments:

Status: Demonstrated

Last Reviewed: 2001

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

Cost estimates assume a conventional design under typical operating conditions. The costs do not include auxiliary equipment such as fans and ductwork. (EPA, 2000)

Costs are primarily based on volumetric flow rate and the amount of PM in the waste stream. In general, a small unit controlling a low pollutant levels will not be as cost effective as a large unit controlling a high pollutant levels. (EPA, 2000)

Pollutants requiring a high level of control or the fabric filters to be constructed of special materials will increase the costs of the system (EPA, 1998a). The additional costs for controlling complex waste streams are not included in the estimates. For these systems, the capital cost could increase by as much as 30% and the O&M cost could increase by as much as 7%.

In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Fabric filters may be in the form of sheets, cartridges, or bags, with many individual filter units together in a group. Bags are the most common type of filter. The dust cake that forms on the filter from the collected PM can significantly increase collection efficiency. (EPA, 2000)

Mechanical shaking is a popular cleaning method because it is both simple and effective. In typical operation, dusty gas enters an inlet pipe to the fabric filter and very large particles are removed using a baffle plate fall into the hopper. The gas stream is drawn from beneath a cell plate in the floor and into the filter bags (EPA, 2000). The gas proceeds from the inside to the outside of the filter bags. The particles collect on the inside of the bags, forming a filter cake. In mechanical shaking units, the tops of bags are attached to a shaker bar, moved briskly (usually in a horizontal direction) to clean the bags. The shaker bars are operated by mechanical motors or by hand (EPA, 1998b)..

Fabric filters are useful for collecting particles with resistivities either too low or too high for collection with electrostatic precipitators. Fabric filters are useful in controlling particulate matter less than or equal to 10 micrometers (μm) in diameter (PM₁₀) and particulate matter less than or equal to 2.5 μm in diameter (PM_{2.5}). Fabric filters may be good candidates for collecting fly ash from low-sulfur coals or containing high unburned carbon levels and are relatively difficult to collect with electrostatic precipitators. (EPA, 2000)

References:

EPA, 1998a: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, Chapter 5, EPA 453/B-96-001, Research Triangle Park, NC. December 1998.

EPA, 1998b: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

EPA, 2000: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Fabric Filter - Mechanical Shaker Cleaned Type," August 2000.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Ferrous Metals Processing - Steel Foundries

Control Measure Name: Dry ESP-Wire Plate Type

Rule Name: Not Applicable

Pechan Measure Code: P2173

POD: 217

Application: This control is the use of dry electrostatic precipitators (ESP) to reduce PM emissions. An ESP uses electrical forces to move particles in an exhaust stream onto collector plates. Electrodes in the center of the flow are maintained at high voltage and generate an electrical field forcing particles to the collector walls. In dry ESPs, the collectors are knocked by various mechanical means to dislodge the particulate, which slides downward into a hopper.

This control applies to ferrous metals processing operations, specifically steel foundries.

Affected SCC:

30400701 Secondary Metal Production, Steel Foundries, Electric Arc Furnace
30400704 Steel Foundries, Heat Treating Furnace
30400705 Steel Foundries, Electric Induction Furnace
30400706 Steel Foundries, Sand Grinding/Handling
30400708 Steel Foundries, Pouring/Casting
30400709 Steel Foundries, Casting Shakeout
30400711 Steel Foundries, Cleaning
30400712 Steel Foundries, Charge Handling
30400713 Steel Foundries, Castings Cooling
30400715 Steel Foundries, Finishing
30400717 Steel Foundries, Core Ovens
30400724 Steel Foundries, Sand Screens
30400799 Steel Foundries, Other Not Classified
30400999 Malleable Iron, Other Not Classified

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: PM10 control efficiency is 98% from uncontrolled; PM2.5 control efficiency is 95% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs for ESPs of conventional design under typical operating conditions are developed using EPA cost estimating spreadsheets (EPA, 1996). When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan, 2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed

AT-A-GLANCE TABLE FOR POINT SOURCES

capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 1999). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$15 to \$50 per scfm
Typical value is \$27 per scfm

O&M Costs:

Range from \$4 to \$40 per scfm
Typical value is \$16 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for ESP (EPA, 1996). O&M costs were calculated for three model plants with flow rates of 200 and 500 thousand acfm and 1 million acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust loading of 6.0 grains per cubic feet. The operating time was assumed to be 8640 hours per year. The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.067	\$/kW-hr
Dust disposal	25	\$/ton disposed

Note: All costs are in 1995 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$40 to \$250 per ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$110 per ton PM10 reduced. (1995\$)

Comments:

Status: Demonstrated	Last Reviewed: 2001
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Additional Information:

In the wire-plate ESP, the gas flows around vertical, metal plates. The electrodes are long, weighted wires hanging between the plates. The voltage applied to the electrodes causes the gas between the electrodes to break down, known as a "corona." The electrodes are most often given a negative

AT-A-GLANCE TABLE FOR POINT SOURCES

polarity because a negative corona supports a higher voltage than a positive corona.

Certain types of losses affect control efficiency. The dislodging of the accumulated layer also projects some of the particles back into the gas stream. These particles are processed in later sections of the ESP, but the particles from the last section have no chance to be recaptured. Due to the space needed at the top of the ESP for nonelectrified components, part of the stream may flow around the charged zones. This is called "sneakage" and places an upper limit on the collection efficiency of the ESP. Anti-sneakage baffles are used to force the sneakage flow to mix with the main gas stream for collection in later sections (EPA, 1998).

Another factor in the performance of ESPs is the resistivity of the collected material. All the ion current must pass through the collected layer to reach the ground plates. This creates an electric field in the layer, and it can become large enough to cause electrical breakdown. When this occurs, new ions of the wrong polarity are injected into the wire-plate gap reducing the charge on the particles, which may cause sparking. This condition is called "back corona." When this happens the collection ability of the unit is reduced. At low resistivities the particles are held on the plates so loosely that reentrainment levels are much higher. Hence, care must be taken in measuring or estimating resistivity because it is strongly affected by such variables as temperature, moisture, gas composition, particle composition, and surface characteristics (EPA, 1999).

Dusts with high resistivities are also not well-suited for collection in dry ESPs. These particles are not easily charged nor easily collected. High-resistivity particles form ash layers with very high voltage gradients on the collecting electrodes lead to back corona, reducing the charge on particles and lowering collection efficiency. Fly ash from the combustion of low-sulfur coal typically has a high resistivity, and thus is difficult to collect using dry ESPs (EPA, 1999).

References:

EPA, 1996: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, EPA 453/B-96-001, Research Triangle Park, NC. February 1996.

EPA, 1998: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

EPA, 1999: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Dry Electrostatic Precipitator (ESP) - Wire-Plate Type," May 1999.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Ferrous Metals Processing - Steel Foundries

Control Measure Name: Wet ESP - Wire Plate Type

Rule Name: Not Applicable

Pechan Measure Code: P2174

POD: 217

Application: This control is the use of a wire-plate type electrostatic precipitator (ESP) to reduce PM emissions. An ESP uses electrical forces to move particles in an exhaust stream onto collector plates. Electrodes in the center of the flow are maintained at high voltage and generate an electrical field forcing particles to the collector walls. Wet ESPs use a stream of water, in place of rapping mechanisms, to dislodge particulate from the plates and into a sump.

This control applies to ferrous metals processing operations, specifically steel foundries.

Affected SCC:

30400701 Secondary Metal Production, Steel Foundries, Electric Arc Furnace
30400704 Steel Foundries, Heat Treating Furnace
30400705 Steel Foundries, Electric Induction Furnace
30400706 Steel Foundries, Sand Grinding/Handling
30400708 Steel Foundries, Pouring/Casting
30400709 Steel Foundries, Casting Shakeout
30400711 Steel Foundries, Cleaning
30400712 Steel Foundries, Charge Handling
30400713 Steel Foundries, Castings Cooling
30400714 Steel Foundries, Shakeout Machine
30400715 Steel Foundries, Finishing
30400716 Secondary Metal Production, Steel Foundries, Sand Grinding/Handling
30400717 Steel Foundries, Core Ovens
30400724 Steel Foundries, Sand Screens
30400799 Steel Foundries, Other Not Classified
30400999 Malleable Iron, Other Not Classified

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: PM10 control efficiency is 99% from uncontrolled; PM2.5 control efficiency is 95% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The following are cost ranges for wire-plate ESPs, developed using EPA cost-estimating spreadsheets for dry wire-plate ESPs with adjustments made to reflect wet wire-plate ESPs (EPA, 1999). Capital and operating costs are generally higher due to noncorrosive materials requirements, increased water usage, and treatment and disposal of wet effluent. When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M

AT-A-GLANCE TABLE FOR POINT SOURCES

costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM₁₀ removed were used (Pechan,2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 1990). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$30 to \$60 per scfm
Typical value is \$40 per scfm

O&M Costs:

Range from \$6 to \$45 per scfm
Typical value is \$19 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for ESP (EPA, 1999). O&M costs were calculated for three model plants with flow rates of 10, 15 and 20 thousand acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust loading of 6.0 grains per cubic feet. The operating time was assumed to be 8640 hours per year. A water flow rate for the ESP was assumed to be 5 gal/min per thousand acfm. The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.067	\$/kW-hr
Process water price	0.20	\$/1000 gal
Dust disposal	20	\$/ton disposed
Wastewater treatment	1.5	\$/ thousand gal treated

Note: All costs are in 1995 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$55 to \$550 per ton PM₁₀ removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$220 per ton PM₁₀ reduced. (1995\$)

Comments:

AT-A-GLANCE TABLE FOR POINT SOURCES

Status: Demonstrated	Last Reviewed: 2001
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Additional Information:

Costs can be substantially higher than in the ranges shown for pollutants which require an unusually high level of control, or which require the ESP to be constructed of special materials such as titanium (EPA, 1999). In most cases, smaller units controlling a low concentration waste stream will not be as cost effective as a large unit cleaning a high pollutant load flow (EPA, 1998).

In the wire-plate ESP, the gas flows around vertical, metal plates. The electrodes are long, weighted wires hanging between the plates. The voltage applied to the electrodes causes the gas between the electrodes to break down, known as a "corona." The electrodes are most often given a negative polarity because a negative corona supports a higher voltage than a positive corona.

Certain types of losses affect control efficiency. The dislodging of the accumulated layer also projects some of the particles back into the gas stream. These particles are processed in later sections of the ESP, but the particles from the last section have no chance to be recaptured. Due to the space needed at the top of the ESP for nonelectrified components, part of the stream may flow around the charged zones. This is called "sneakage" and places an upper limit on the collection efficiency of the ESP. Anti-sneakage baffles are used to force the sneakage flow to mix with the main gas stream for collection in later sections (EPA, 1998).

Wire-Plate Type Wet ESPs require a source of wash water near the top of the collector plates. This wash system replaces the rapping mechanism used by dry ESPs. The water flows with the collected particles into a sump from which the fluid is pumped or drained. A portion of the fluid may be recycled to reduce the total amount of water required. The remainder is pumped into a settling pond or passed through a dewatering stage, with subsequent disposal of the sludge (AWMA, 1992).

Unlike dry ESPs, resistivity of the collected material is not a major factor in performance. Because of the high humidity in a wet ESP, the resistivity of particles is lowered, eliminating the "back corona" condition. The frequent washing of the plates also limits particle buildup on the collectors (EPA, 1998).

For wet ESPs, the handling wastewaters must be considered (EPA, 1999). For simple systems with innocuous dusts, water with particles collected by the ESP may be discharged from the ESP system to a solids-removing clarifier. More complicated systems may require skimming and sludge removal, clarification in dedicated equipment, pH adjustment, and/or treatment to remove dissolved solids. Recirculation of treated water to the ESP may approach 100 percent (AWMA, 1992).

References:

AWMA, 1992: Air & Waste Management Association, Air Pollution Engineering Manual, Van Nostrand Reinhold, New York.

EPA, 1996: U.S. EPA, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, EPA 453/B-96-001, Research Triangle Park, NC. February.

EPA, 1998: U.S. EPA, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October.

EPA, 1999: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Wet Electrostatic Precipitator (ESP) - Wire-Plate Type," May 1999

AT-A-GLANCE TABLE FOR POINT SOURCES

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Ferrous Metals Processing - Steel Foundries

Control Measure Name: Fabric Filter (Reverse-Air Cleaned Type)

Rule Name: Not Applicable

Pechan Measure Code: P2175

POD: 217

Application: This control is the use of a reverse-air cleaned fabric filter to reduce PM emissions from waste streams. In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Reverse-air cleaning is performed by forcing clean air through the filters in the opposite direction of the dusty gas flow. The change in direction of the gas flow causes the bag to flex and crack the filter cake allowing for internal cake collection.

This control applies to ferrous metals processing operations, specifically steel foundries.

Affected SCC:

30400701 Secondary Metal Production, Steel Foundries, Electric Arc Furnace
30400704 Steel Foundries, Heat Treating Furnace
30400705 Steel Foundries, Electric Induction Furnace
30400706 Steel Foundries, Sand Grinding/Handling
30400708 Steel Foundries, Pouring/Casting
30400709 Steel Foundries, Casting Shakeout
30400711 Steel Foundries, Cleaning
30400712 Steel Foundries, Charge Handling
30400713 Steel Foundries, Castings Cooling
30400714 Steel Foundries, Shakeout Machine
30400715 Steel Foundries, Finishing
30400716 Secondary Metal Production, Steel Foundries, Sand Grinding/Handling
30400717 Steel Foundries, Core Ovens
30400724 Steel Foundries, Sand Screens
30400799 Steel Foundries, Other Not Classified
30400999 Malleable Iron, Other Not Classified

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 99% from uncontrolled for both PM10 and PM2.5

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs for reverse-air cleaned systems are generated using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan,2001).

AT-A-GLANCE TABLE FOR POINT SOURCES

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 2000). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$9 to \$84 per scfm
Typical value is \$34 per scfm

O&M Costs:

Range from \$6 to \$27 per scfm
Typical value is \$13 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). O&M costs were calculated for three model plants with flow rates of 25, 75 and 150 thousand acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust loading of 4.0 grains per cubic feet. The operating time was assumed to be 8760 hours per year. An average bag cost was estimated using the costs for standard bag types. Capital recovery for the periodic replacement of bags was included in the O&M cost of the bags using a bag life of 2 years (EPA, 1998a). The following assumptions apply to the cost of utilities and disposal:

Electricity price □0.0671 □\$/kW-hr
Compressed air □0.25 □\$/1000 scf
Dust disposal □25 □\$/ton disposed

Note: All costs are in 1998 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$53 to \$337 per ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$148 per ton PM10 reduced. (1998\$)

Comments:

Status: Demonstrated

Last Reviewed: 2001

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

The cost estimates assume a conventional design under typical operating conditions. The costs do not include any auxiliary equipment (EPA, 2000).

The capital cost for the reverse-jet cleaned fabric baghouse is based on information provided by a manufacturer (EPA, 2000). The capital cost includes only the purchased equipment cost.

Costs are primarily based on volumetric flow rate and the amount of PM in the waste stream. In general, a small unit controlling a low pollutant levels will not be as cost effective as a large unit controlling a high pollutant levels. (EPA, 2000)

Pollutants requiring a high level of control or the fabric filters to be constructed of special materials will increase the costs of the system (EPA, 1998a). The additional costs for controlling complex streams are not reflected in the estimates. For these systems, the capital cost could increase by as much as 40% and the O&M cost could increase by as much as 5%. (EPA, 2000)

In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Fabric filters may be in the form of sheets, cartridges, or bags, with many individual filter units together in a group. Bags are the most common type of filter. The dust cake that forms on the filter from the collected PM can significantly increase collection efficiency. (EPA, 2000)

Reverse-air cleaning is a popular filter cleaning method as it has been used extensively and improved over the years. It is a gentler but sometimes less effective clearing mechanism than mechanical shaking. Reverse-air cleaning is performed by forcing clean air through the filters in the opposite direction of the dusty gas flow. The change in direction of the gas flow causes the bag to flex and crack the filter cake allowing for internal cake collection (EPA, 2000).

The most common design is to have separate compartments within the fabric filter so that each can be isolated and cleaned separately while the others continue to treat the dusty gas. There are several methods of reversing the flow through the filters. One method of providing the reverse flow is by the use of a fan or cleaned gas from other compartments. Reverse-air cleaning only used alone in cases where the dust releases easily from the fabric. In many instances, reverse-air is used along with shaking, pulsing or sonic horns (EPA, 1998b).

Fabric filters are useful for collecting particles with resistivities either too low or too high for collection with electrostatic precipitators. Fabric filters are useful in controlling particulate matter less than or equal to 10 micrometers (μm) in diameter (PM₁₀) and particulate matter less than or equal to 2.5 μm in diameter (PM_{2.5}). Fabric filters may be good candidates for collecting fly ash from low-sulfur coals or containing high unburned carbon levels and are relatively difficult to collect with electrostatic precipitators. (EPA, 2000)

References:

EPA, 1998b: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

EPA, 1998a: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, Chapter 5, EPA 453/B-96-001, Research Triangle Park, NC. December 1998.

EPA, 2000: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution

AT-A-GLANCE TABLE FOR POINT SOURCES

Technology Fact Sheet - Fabric Filter - Reverse-Air Cleaned Type," April 2000.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Ferrous Metals Processing - Steel Foundries

Control Measure Name: Venturi Scrubber

Rule Name: Not Applicable

Pechan Measure Code: P2176

POD: 217

Application: The control is the use of a venturi scrubber to reduce PM emissions. A scrubber is a type of technology that removes air pollutants by inertial and diffusional interception. A venturi scrubber accelerates the waste gas stream to atomize the scrubbing liquid and to improve gas-liquid contact.

This control applies to ferrous metals processing operations, specifically steel foundries.

Affected SCC:

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: PM10 control efficiency is 73% from uncontrolled; PM2.5 control efficiency is 25% from uncontrolled

Equipment Life: 10 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The following are cost ranges for venturi wet scrubbers, developed using EPA cost-estimating spreadsheets (EPA, 1996) and referenced to the volumetric flow rate of the waste stream treated. When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan,2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 1999). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (10 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual,

AT-A-GLANCE TABLE FOR POINT SOURCES

with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$3 to \$28 per scfm
Typical value is \$11 per scfm

O&M Costs:

Range from \$4 to \$119 per scfm
Typical value is \$42 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for Impingement Plate Scrubbers (EPA, 1996). O&M costs were calculated for two model plants with flow rates of 2,000 and 150,000 acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. The model plants were assumed to have a dust loading of 3.0 grains per cubic feet. The operating time was assumed to be 8760 hours per year. An inlet water flow rate for the scrubber was assumed to be 9.4 lbs/min. The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.067	\$/kW-hr
Process water price	0.20	\$/1000 gal
Dust disposal	25	\$/ton disposed
Wastewater treatment	3.8	\$/ thousand gal treated

Note: All costs are in 1995 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$76 to \$2,100 per ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$751 per ton PM10 reduced. (1995\$)

Comments:

Status: Demonstrated	Last Reviewed: 2001
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Additional Information:

The costs do not include costs for post-treatment or disposal of used solvent or waste. Actual costs can be substantially higher than in the ranges shown for applications which require expensive materials, solvents, or treatment methods (EPA, 1999). As a rule, smaller units controlling a low concentration waste stream will be much more expensive (per unit volumetric flow rate) than a large unit cleaning a high pollutant load flow.

By product coke production is used to manufacture metallurgical coke by heating high-grade bituminous coal (low sulfur and low ash) in an enclosed oven chamber without oxygen. The resulting solid material consists of elemental carbon and any minerals (ash) that were present in the coal blend that did not volatilize during the process. Sources of air emissions consist of coke oven doors, coke oven lids and off-takes, coke oven charging, coke oven pushing, coke oven underfire stack, coke quenching, battery venting, and coke by-product-recovery plants.

A venturi scrubber accelerates the waste gas stream to improve gas-liquid contact. In a venturi

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scrubber, a "throat" section is built into the duct that forces the gas stream to accelerate (EPA, 1999). As the gas enters the venturi throat, both gas velocity and turbulence increase.

After the throat section, the mixture decelerates, and further impacts occur causing the droplets to agglomerate. Once the particles have been captured by the liquid, the wetted PM and excess liquid are separated from the gas stream through entrainment. This section usually consists of a cyclonic separator and/or a mist eliminator (EPA, 1998; Corbitt, 1990).

For PM applications, wet scrubbers generate waste, either a slurry or wet sludge. This creates the need for both wastewater treatment and solid waste disposal. Initially, the slurry is treated to separate the solid waste from the water (EPA, 1999). The treated water can then be reused or discharged. Once the water is removed, the remaining waste will be in the form of a solid or sludge. If the solid waste is inert and nontoxic, it can generally be land filled. Hazardous wastes will have more stringent procedures for disposal. In some cases, the solid waste may have value and can be sold or recycled (EPA, 1998).

References:

Corbitt, 1990: "Standard Handbook of Environmental Engineering," edited by Robert A. Corbitt, McGraw-Hill, New York, NY, 1990.

EPA, 1996: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, EPA 453/B-96-001, Research Triangle Park, NC February.

EPA, 1998: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

EPA, 1999: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Venturi Scrubber," July 1999.

Heumann, 1997: W. L. Heumann, "Industrial Air Pollution Control Systems," McGraw Hill Publishers, Inc., Washington, D.C., 1997.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

STAPPA/ALAPCO, 1996: State and Territorial Air Pollution Program Administrators and Association of Local Air Pollution Control Officials, "Controlling Particulate Matter Under the Clean Air Act: A Menu of Options," July 1996.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Ferrous Metals Processing - Steel Foundries

Control Measure Name: Increased Monitoring Frequency (IMF) of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P3217

POD: 217

Application: This measure is to conduct improved monitoring for PM_{2.5} emissions at stationary sources. Improved monitoring in this case means increasing the monitoring frequency of electrostatic precipitators, scrubbers, and fabric filters from once per day to four times per hour, with no change in monitoring technique.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (Barr and Schaffner) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

304007** Secondary Metal Production, Steel Foundries

304009** Secondary Metal Production, Malleable Iron

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 6.5% for both PM₁₀ and PM_{2.5}

Equipment Life: Not applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs included the incremental record keeping and reporting associated with the increased monitoring frequency. Labor rates for 2003 were made that were obtained from the Bureau of Labor Statistics (labor rates include 140 percent overhead). The incremental costs included a one-time cost for development of the improved monitoring and recurring annual burden costs for incremental record keeping, reporting, and certification activities.

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$620 per ton PM reduced (2003\$).

Comments:

Status:

Last Reviewed: 2004

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM2.5 Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 2003.

BLS, 2003: Bureau of Labor Statistics, "Employer Costs for Employee Compensation – June 2003," Table 12, page 16, 2003.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Ferrous Metals Processing - Steel Foundries

Control Measure Name: CEM Upgrade and Increased Monitoring Frequency of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P4217

POD: 217

Application: This measure examines the impacts of improving the PM monitoring technique at units currently using an ESP, scrubber, or fabric filter. In this improved technique scenario, the monitoring technique is upgraded to a PM continuous emission monitor. This improved monitoring technique also results in an increase to the monitoring frequency because a PM CEMS can make a measurement every 7.5 minutes. The monitoring frequency increases from once per day to eight times per hour.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (see References) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

304007** Secondary Metal Production, Steel Foundries

304009** Secondary Metal Production, Malleable Iron

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 7.7% for both PM10 and PM2.5

Equipment Life: Unknown

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The total capital and annual operating costs for implementing an improved monitoring technique are calculated based on data from the EPA CEMS Cost Model and the PM CEMS Knowledge document. Labor rates in the EPA CEMS Cost Model are scaled to reflect 2003 labor rates (including 140 percent overhead) provided by the Bureau of Labor Statistics.

The cost effectiveness at a percent excess emission rate of 0.46 percent is \$5,200 per ton of PM2.5. This is based on a \$34 million capital investment cost, and a \$14 million total annualized cost when applied to 128 facilities.

Note: All costs are in 2003 dollars.

AT-A-GLANCE TABLE FOR POINT SOURCES

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$5,200 per ton PM reduced (2003\$).

Comments:

Status:

Last Reviewed: 2004

Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM_{2.5} Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 8, 2003.

EPA CEMS Cost Model, Version 3.0, U.S. Environmental Protection Agency.

EPA, 2000: U.S. Environmental Protection Agency, "Current Knowledge of Particulate Matter (PM) Continuous Emissions Monitoring," Chapter 9, PM CEMS Cost, September 8, 2000.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Grain Milling

Control Measure Name: Fabric Filter (Pulse Jet Type)

Rule Name: Not Applicable

Pechan Measure Code: P2231

POD: 223

Application: This control is the addition of a pulse-jet cleaned fabric filter to reduce PM emissions from waste streams. In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Particulate-laden gas flows into the filter bag from the outside to the inside. The particles collected on the outside drop into a hopper below the fabric filter. During pulse-jet cleaning, a short burst of high pressure air is injected into the bags, dislodging the dust cake.

This control applies to grain milling operations, including (but not limited to), wheat, dry corn, wet corn, rice, and soybean operations.

Affected SCC:

30200701 Grain Millings, General **
30200702 Grain Millings, General **
30200730 Grain Millings, General **
30200731 Grain Millings, Wheat: Grain Receiving
30200732 Grain Millings, Wheat: Precleaning/Handling
30200733 Grain Millings, Wheat: Cleaning House
30200734 Grain Millings, Wheat: Millhouse
30200741 Grain Millings, Dry Corn Milling: Grain Receiving
30200742 Food and Agriculture, Grain Millings, Dry Corn Milling: Grain Drying
30200743 Food and Agriculture, Grain Millings, Dry Corn Milling: Precleaning/Handling
30200744 Grain Millings, Dry Corn Milling: Cleaning House
30200745 Food and Agriculture, Grain Millings, Dry Corn Milling: Degerming and Milling
30200751 Grain Millings, Wet Corn Milling: Grain Receiving
30200752 Grain Millings, Wet Corn Milling: Grain Handling
30200753 Grain Millings, Wet Corn Milling: Grain Cleaning
30200754 Grain Millings, Wet Corn Milling: Dryers
30200755 Grain Millings, Wet Corn Milling: Bulk Loading
30200756 Grain Millings, Wet Corn Milling: Milling
30200771 Grain Millings, Rice: Grain Receiving
30200772 Grain Millings, Rice: Precleaning/Handling
30200773 Grain Millings, Rice: Drying
30200781 Grain Millings, Soybean: Grain Receiving
30200782 Grain Millings, Soybean: Grain Handling
30200783 Grain Millings, Soybean: Grain Cleaning
30200784 Grain Millings, Soybean: Drying
30200785 Grain Millings, Soybean: Cracking and Dehulling
30200786 Grain Millings, Soybean: Hull Grinding
30200787 Grain Millings, Soybean: Bean Conditioning
30200788 Food and Agriculture, Grain Millings, Soybean: Flaking
30200789 Food and Agriculture, Grain Millings, Soybean: Meal Dryer
30200790 Food and Agriculture, Grain Millings, Soybean: Meal Cooler
30200791 Food and Agriculture, Grain Millings, Soybean: Bulk Loading
30200799 Grain Millings, **

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Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 99% from uncontrolled for both PM10 and PM2.5

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs for pulse-jet cleaned systems are generated using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan,2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 2000). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$6 to \$26 per scfm

Typical value is \$13 per scfm

O&M Costs:

Range from \$5 to \$24 per scfm

Typical value is \$11 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). O&M costs were calculated for three model plants with flow rates of 25, 75 and 150 thousand acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust loading of 4.0 grains per cubic feet. The operating time was assumed to be 8760 hours per year. An average bag cost was estimated using the costs for standard bag

AT-A-GLANCE TABLE FOR POINT SOURCES

types. Capital recovery for the periodic replacement of bags was included in the O&M cost of the bags using a bag life of 2 years (EPA, 1998a). The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.0671	\$/kW-hr
Compressed air	0.25	\$/1000 scf
Dust disposal	25	\$/ton disposed

Note: All costs are in 1998 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$42 to \$266 per ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$117 per ton PM10 reduced. (1998\$)

Comments:

Status: Demonstrated	Last Reviewed: 2001
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Additional Information:

The cost estimates assume a conventional design under typical operating conditions and do not include auxiliary equipment such as fans and ductwork. The costs for pulse-jet cleaned systems are generated using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a).

Costs are primarily based on volumetric flow rate and the amount of PM in the waste stream. In general, a small unit controlling a low pollutant levels will not be as cost effective as a large unit controlling a high pollutant levels. (EPA, 2000)

Pollutants requiring a high level of control or the fabric filters to be constructed of special materials will increase the costs of the system (EPA, 1998a). The additional costs for controlling complex waste streams are not included in the estimates. For these systems, the capital cost could increase by as much as 75% and the operational and maintenance (O&M) cost could increase by as much as 20% (EPA, 2000).

In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Fabric filters may be in the form of sheets, cartridges, or bags, with many individual filter units together in a group. Bags are the most common type of filter. The dust cake that forms on the filter from the collected PM can significantly increase collection efficiency. (EPA, 2000)

Pulse-jet cleaning of fabric filters is a relatively new type of fabric filter, as they have only been used for the past 30 years. This cleaning mechanism has grown in popularity because it can treat high dust loadings, operate at constant pressure drop, and occupy less space than other types of fabric filters (EPA, 2000). Particulate-laden gas flows into the bag. The gas flows from the outside to the inside of the bags, and then out the gas exhaust. The particles collected on the outside drop into a hopper below the fabric filter (EPA, 1998b).

During pulse-jet cleaning, a short burst of high pressure air is injected into the bags (EPA, 1998b). The pulse is blown through a venturi nozzle at the top of the bags and establishes a shock wave that continues onto the bottom of the bag. The wave flexes the fabric dislodging the dust cake.

There are several unique attributes of pulse-jet cleaning. The cleaning pulse is very brief allowing the flow of dusty gas to continue during cleaning. The bags not being cleaned continue to filter,

AT-A-GLANCE TABLE FOR POINT SOURCES

taking on extra duty from the bags being cleaned (EPA, 2000). Pulse-jet cleaning is more intense and occurs with greater frequency than the other fabric filter cleaning methods. The cleaning dislodges nearly all of the dust cake each time the bag is pulsed. Pulse-jet filters, as a result, do not rely on a dust cake to provide filtration. Felted (non-woven) fabrics are used in these types of filters because they do not require a dust cake. Also it has been found that woven fabrics used with pulse-jet cleaning leak dust after they are cleaned (EPA, 1998b).

Since bags cleaned by the pulse-jet method do not need to be isolated for cleaning, pulsejet cleaned fabric filters do not need extra compartments to maintain adequate filtration during cleaning. Also, because of the intense and frequent nature of the cleaning, they can treat higher gas flow rates with higher dust loadings. Consequently, fabric filters cleaned by the pulse-jet method can be smaller than other filters in the treatment of the same amount of gas and dust, making higher gas-to-cloth ratios achievable (EPA, 1998b).

Fabric filters are useful for collecting particles with resistivities either too low or too high for collection with electrostatic precipitators. Fabric filters are useful in controlling particulate matter less than or equal to 10 micrometers (μm) in diameter (PM10) and particulate matter less than or equal to 2.5 μm in diameter (PM2.5). Fabric filters may be good candidates for collecting fly ash from low-sulfur coals or containing high unburned carbon levels and are relatively difficult to collect with electrostatic precipitators. (EPA, 2000)

References:

EPA, 1998a: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, Chapter 5, EPA 453/B-96-001, Research Triangle Park, NC. December 1998.

EPA, 1998b: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

EPA, 2000: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Fabric Filter - Pulse-Jet Cleaned Type," April 2000.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Grain Milling

Control Measure Name: Paper/Nonwoven Filters - Cartridge Collector Type

Rule Name: Not Applicable

Pechan Measure Code: P2232

POD: 223

Application: This control is the use of paper or non-woven filters (cartridge collector type) to reduce PM emissions. The waste gas stream is passed through the fibrous filter media causing PM in the gas stream to be collected on the media by sieving and other mechanisms.

This control measure applies to grain milling operations, including those involved with the production of wheat, corn, rice, and soybeans, among others.

Affected SCC:

30200701 Grain Millings, General **
30200702 Grain Millings, General **
30200730 Grain Millings, General **
30200731 Grain Millings, Wheat: Grain Receiving
30200732 Grain Millings, Wheat: Precleaning/Handling
30200733 Grain Millings, Wheat: Cleaning House
30200734 Grain Millings, Wheat: Millhouse
30200741 Grain Millings, Dry Corn Milling: Grain Receiving
30200742 Food and Agriculture, Grain Millings, Dry Corn Milling: Grain Drying
30200743 Food and Agriculture, Grain Millings, Dry Corn Milling: Precleaning/Handling
30200744 Grain Millings, Dry Corn Milling: Cleaning House
30200745 Food and Agriculture, Grain Millings, Dry Corn Milling: Degerming and Milling
30200751 Grain Millings, Wet Corn Milling: Grain Receiving
30200752 Grain Millings, Wet Corn Milling: Grain Handling
30200753 Grain Millings, Wet Corn Milling: Grain Cleaning
30200754 Grain Millings, Wet Corn Milling: Dryers
30200755 Grain Millings, Wet Corn Milling: Bulk Loading
30200756 Grain Millings, Wet Corn Milling: Milling
30200771 Grain Millings, Rice: Grain Receiving
30200772 Grain Millings, Rice: Precleaning/Handling
30200773 Grain Millings, Rice: Drying
30200781 Grain Millings, Soybean: Grain Receiving
30200782 Grain Millings, Soybean: Grain Handling
30200783 Grain Millings, Soybean: Grain Cleaning
30200784 Grain Millings, Soybean: Drying
30200785 Grain Millings, Soybean: Cracking and Dehulling
30200786 Grain Millings, Soybean: Hull Grinding
30200787 Grain Millings, Soybean: Bean Conditioning
30200788 Food and Agriculture, Grain Millings, Soybean: Flaking
30200789 Food and Agriculture, Grain Millings, Soybean: Meal Dryer
30200790 Food and Agriculture, Grain Millings, Soybean: Meal Cooler
30200791 Food and Agriculture, Grain Millings, Soybean: Bulk Loading
30200799 Grain Millings, **

AT-A-GLANCE TABLE FOR POINT SOURCES

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 99% from uncontrolled for both PM10 and PM2.5

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs are generated using EPA's cost-estimating spreadsheets for fabric filters (EPA, 1998a). Costs are primarily driven by the waste stream volumetric flow rate and pollutant loading. When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan,2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 2000). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$7 to \$13 per scfm
Typical value is \$9 per scfm

O&M Costs:

Range from \$9 to \$25 per scfm
Typical value is \$14 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). O&M costs were calculated for three model plants with flow rates of 25, 75 and 150 thousand acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust loading of 4.0 grains per cubic feet. The operating time was assumed to be 8760 hours per year. An average cartridge cost was estimated using the costs for standard

AT-A-GLANCE TABLE FOR POINT SOURCES

cartridge types. Capital recovery for the periodic replacement of cartridges was included in the O&M cost of the cartridges using a cartridge life of 2 years (EPA, 1998a). The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.0671	\$/kW-hr
Compressed air	0.25	\$/1000 scf
Dust disposal	25	\$/ton disposed

Note: All costs are in 1998 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$85 to \$256 per ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$142 per ton PM10 reduced. (1998\$)

Comments:

Status: Demonstrated	Last Reviewed: 2001
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Additional Information:

The cost estimates assume a conventional design under typical operating conditions. Auxiliary equipment, such as fans and ductwork, is not included (EPA, 2000). Pollutants that require an unusually high level of control or that require the filter media or the unit itself to be constructed of special materials, such as Nomex ® or stainless steel, will increase the costs of the system (EPA, 1998a). The additional costs for controlling more complex waste streams are not reflected in the estimates given below. For these types of systems, the capital cost could increase by as much as 75% and the O&M cost could increase by as much as 10%. In general, a small unit controlling a low pollutant loading will not be as cost effective as a large unit controlling a high pollutant loading (EPA, 2000).

Cartridge filters contain either a paper or nonwoven fibrous filter media (EPA, 2000). Paper media is generally made of materials such as cellulose and fiberglass. The dust cake that forms on the filter media from the collected PM can significantly increase collection efficiency (EPA, 1998b).

In general, the filter media is pleated to provide a larger surface area to volume flow rate. Close pleating, however, can cause PM to bridge the pleat bottom, effectively reducing the surface collection area (EPA, 1998b). Corrugated aluminum separators are used to prevent the pleats from collapsing (Heumann, 1997). There are variety of cartridge designs and dimensions. Typical designs include flat panels, V-shaped packs or cylindrical packs (Heumann, 1997). For certain applications, two cartridges may be placed in series.

Cartridge collectors are useful for collecting particles with resistivities either too low or too high for collection with electrostatic precipitators (STAPPA/ALAPCO, 1996). For similar air flow rates, cartridge collectors are compact in size compared to traditional bag

References:

EPA, 1998b: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, Chapter 5, EPA 453/B-96-001, Research Triangle Park, NC. December 1998.

EPA, 1998a: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

AT-A-GLANCE TABLE FOR POINT SOURCES

EPA, 2000: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Cartridge Collector with Pulse-Jet Cleaning," April 2000.

Heumann, 1997: W. L. Heumann, "Industrial Air Pollution Control Systems," McGraw Hill Publishers, Inc., Washington, D.C., 1997.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

STAPPA/ALAPCO, 1996: State and Territorial Air Pollution Program Administrators and Association of Local Air Pollution Control Officials, "Controlling Particulate Matter Under the Clean Air Act: A Menu of Options," July 1996.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Grain Milling

Control Measure Name: Fabric Filter (Reverse-Air Cleaned Type)

Rule Name: Not Applicable

Pechan Measure Code: P2233

POD: 223

Application: This control is the use of a reverse-air cleaned fabric filter to reduce PM emissions from waste streams. In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Reverse-air cleaning is performed by forcing clean air through the filters in the opposite direction of the dusty gas flow. The change in direction of the gas flow causes the bag to flex and crack the filter cake allowing for internal cake collection.

This control applies to grain milling operations, including (but not limited to), wheat, dry corn, wet corn, rice, and soybean operations.

Affected SCC:

30200701 Grain Millings, General **
30200702 Grain Millings, General **
30200730 Grain Millings, General **
30200731 Grain Millings, Wheat: Grain Receiving
30200732 Grain Millings, Wheat: Precleaning/Handling
30200733 Grain Millings, Wheat: Cleaning House
30200734 Grain Millings, Wheat: Millhouse
30200741 Grain Millings, Dry Corn Milling: Grain Receiving
30200742 Food and Agriculture, Grain Millings, Dry Corn Milling: Grain Drying
30200743 Food and Agriculture, Grain Millings, Dry Corn Milling: Precleaning/Handling
30200744 Grain Millings, Dry Corn Milling: Cleaning House
30200745 Food and Agriculture, Grain Millings, Dry Corn Milling: Degerming and Milling
30200751 Grain Millings, Wet Corn Milling: Grain Receiving
30200752 Grain Millings, Wet Corn Milling: Grain Handling
30200753 Grain Millings, Wet Corn Milling: Grain Cleaning
30200754 Grain Millings, Wet Corn Milling: Dryers
30200755 Grain Millings, Wet Corn Milling: Bulk Loading
30200756 Grain Millings, Wet Corn Milling: Milling
30200771 Grain Millings, Rice: Grain Receiving
30200772 Grain Millings, Rice: Precleaning/Handling
30200773 Grain Millings, Rice: Drying
30200781 Grain Millings, Soybean: Grain Receiving
30200782 Grain Millings, Soybean: Grain Handling
30200783 Grain Millings, Soybean: Grain Cleaning
30200784 Grain Millings, Soybean: Drying
30200785 Grain Millings, Soybean: Cracking and Dehulling
30200786 Grain Millings, Soybean: Hull Grinding
30200787 Grain Millings, Soybean: Bean Conditioning
30200788 Food and Agriculture, Grain Millings, Soybean: Flaking
30200789 Food and Agriculture, Grain Millings, Soybean: Meal Dryer
30200790 Food and Agriculture, Grain Millings, Soybean: Meal Cooler
30200791 Food and Agriculture, Grain Millings, Soybean: Bulk Loading
30200799 Grain Millings, **

AT-A-GLANCE TABLE FOR POINT SOURCES

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 99% from uncontrolled for both PM10 and PM2.5

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs for reverse-air cleaned systems are generated using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan, 2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 2000). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$9 to \$84 per scfm

Typical value is \$34 per scfm

O&M Costs:

Range from \$6 to \$27 per scfm

Typical value is \$13 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). O&M costs were calculated for three model plants with flow rates of 25, 75 and 150 thousand acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust loading of 4.0 grains per cubic feet. The operating time was assumed to be 8760 hours per year. An average bag cost was estimated using the costs for standard bag

AT-A-GLANCE TABLE FOR POINT SOURCES

types. Capital recovery for the periodic replacement of bags was included in the O&M cost of the bags using a bag life of 2 years (EPA, 1998a). The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.0671	\$/kW-hr
Compressed air	0.25	\$/1000 scf
Dust disposal	25	\$/ton disposed

Note: All costs are in 1998 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$53 to \$337 per ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$148 per ton PM10 reduced. (1998\$)

Comments:

Status: Demonstrated	Last Reviewed: 2001
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Additional Information:

The cost estimates assume a conventional design under typical operating conditions. The costs do not include any auxiliary equipment (EPA, 2000).

The capital cost for the reverse-jet cleaned fabric baghouse is based on information provided by a manufacturer (EPA, 2000). The capital cost includes only the purchased equipment cost.

Costs are primarily based on volumetric flow rate and the amount of PM in the waste stream. In general, a small unit controlling a low pollutant levels will not be as cost effective as a large unit controlling a high pollutant levels. (EPA, 2000)

Pollutants requiring a high level of control or the fabric filters to be constructed of special materials will increase the costs of the system (EPA, 1998a). The additional costs for controlling complex streams are not reflected in the estimates. For these systems, the capital cost could increase by as much as 40% and the O&M cost could increase by as much as 5%. (EPA, 2000)

In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Fabric filters may be in the form of sheets, cartridges, or bags, with many individual filter units together in a group. Bags are the most common type of filter. The dust cake that forms on the filter from the collected PM can significantly increase collection efficiency. (EPA, 2000)

Reverse-air cleaning is a popular filter cleaning method as it has been used extensively and improved over the years. It is a gentler but sometimes less effective clearing mechanism than mechanical shaking. Reverse-air cleaning is performed by forcing clean air through the filters in the opposite direction of the dusty gas flow. The change in direction of the gas flow causes the bag to flex and crack the filter cake allowing for internal cake collection (EPA, 2000).

The most common design is to have separate compartments within the fabric filter so that each can be isolated and cleaned separately while the others continue to treat the dusty gas. There are several methods of reversing the flow through the filters. One method of providing the reverse flow is by the use of a fan or cleaned gas from other compartments. Reverse-air cleaning only used alone in cases where the dust releases easily from the fabric. In many instances, reverse-air is used along with shaking, pulsing or sonic horns (EPA, 1998b).

AT-A-GLANCE TABLE FOR POINT SOURCES

Fabric filters are useful for collecting particles with resistivities either too low or too high for collection with electrostatic precipitators. Fabric filters are useful in controlling particulate matter less than or equal to 10 micrometers (μm) in diameter (PM10) and particulate matter less than or equal to 2.5 μm in diameter (PM2.5). Fabric filters may be good candidates for collecting fly ash from low-sulfur coals or containing high unburned carbon levels and are relatively difficult to collect with electrostatic precipitators. (EPA, 2000)

References:

EPA, 1998b: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter, EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

EPA, 1998a: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, Chapter 5, EPA 453/B-96-001, Research Triangle Park, NC. December 1998.

EPA, 2000: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Fabric Filter - Reverse-Air Cleaned Type," April 2000.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

AT-A-GLANCE TABLE FOR MOBILE SOURCES

Source Category: Highway Vehicles - Gasoline Engine

Control Measure Name: RFG and High Enhanced I/M Program

Rule Name: Not Applicable

Pechan Measure Code: mOT7

POD: N/A

Application: This control measure represents a combination of the year round national use of Federal Reformulated gasoline and an enhanced I/M program for light duty gasoline vehicles. Emission reduction benefits of NO_x, CO, and VOC are estimated using EPA's MOBILE6 model.

This control is applicable to all light duty gasoline vehicles, motor cycles, and trucks.

Affected SCC:

2201001000 Light Duty Gasoline Vehicles (LDGV), Total: All Road Types
2201020000 Light Duty Gasoline Trucks 1 (LDGT1), Total: All Road Types
2201040000 Light Duty Gasoline Trucks 2 (LDGT2), Total: All Road Types
2201070000 Heavy Duty Gasoline Vehicles (HDGV), Total: All Road Types
2201080000 Motorcycles (MC), Total: All Road Types

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√	√*			√	

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: The control efficiency ranged from: NO_x (-1.6 % to 13.51%; VOC (-9.1 to 31.9%); CO (-2.1 to 35.4%)

Equipment Life: Not Applicable

Rule Effectiveness: Not applicable

Penetration: Not applicable

Cost Basis: The total annual cost was estimated using the number of vehicles and amount of fuel consumed by county and vehicle type. Costs were estimated on a per-vehicle basis in all counties with no RFG in the base case.

The number of vehicles was estimated by dividing the VMT by the average LDGV annual mileage accumulation rate. The annual costs for is estimated assuming \$0.043 per gallon for RFG and \$17.95 per vehicle inspected in counties with no I/M program and \$11.43 per vehicle inspected in counties with current basic or low I/M program (Pechan 2002). All costs are \$1997.

Cost Effectiveness: The cost effectiveness of varies greatly by county. Cost effectiveness for VOC ranged from \$1,180,340 to negative \$484 per ton. The average C-E for VOC is \$16,164 per ton of VOC reduced (median is \$8,093 per ton). All costs are \$1997.

Comments: In some cases this control produces a slight NO_x disbenefit.

Status: Demonstrated

Last Reviewed: 2002

Additional Information:

AT-A-GLANCE TABLE FOR MOBILE SOURCES

References:

Pechan 2002: "AirControlNET Specifications and Methods for Mobile Source Controls" Memo prepared for Larry Sorrels of the US EPA, December 2002.

AT-A-GLANCE TABLE FOR MOBILE SOURCES

Source Category: Highway Vehicles - Heavy Duty Diesel Engines

Control Measure Name: Voluntary Diesel Retrofit Program: Diesel Particulate Filter

Rule Name: Not Applicable

Pechan Measure Code: HDR199

POD:

Application: This control measure represents the application of EPA's voluntary diesel retrofit program through the use of the diesel particulate filter as a retrofit technology in 1999. Emissions reduction benefits of CO, VOC, PM10, PM2.5, and SO2 are estimated using EPA's MOBILE6 model and independent research on the percent reductions yielded by this control measure.

This control is applicable to all heavy duty diesel vehicles. Light duty and gasoline-fueled vehicles are not affected by this control.

Affected SCC:

2230070000 Heavy Duty Diesel Vehicles (HDDV), Total: All Road Types

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√				√	√		√	

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: The control efficiencies for the affected pollutants are: PM10 (61.99%); PM2.5 (62.26%); VOC (60%), SO2 (97%); CO (60%)

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: To calculate costs for the use of the diesel particulate filter as a retrofit technology, the assumption was made that all relevant vehicles would be affected by the control. Therefore, all heavy duty diesel vehicles were assumed to employ the diesel particulate filter as a retrofit technology through the voluntary diesel retrofit program. The average costs for the diesel particulate filter range from \$3,000 to \$10,000 (Pechan, 2003). Prices vary depending on the size of the engine being retrofit, the sales volume, the amount of particulate matter emitted by the engine, the emission target that must be achieved, the regeneration method, and other factors. For this AirControlNET analysis, an average estimated cost of \$6,500 per heavy duty diesel vehicle was used.

Diesel particulate filters require the use of low sulfur diesel fuel. The costs for the low sulfur diesel fuel were applied to all gallons of diesel fuel used by the heavy duty diesel vehicles. Low sulfur diesel fuel is estimated to cost an additional \$0.05 per gallon of diesel (EPA, 2000). All costs are in 1999 dollars.

Cost Effectiveness: The cost effectiveness of the diesel particulate filter varies greatly by county and depends mostly on the number of vehicles. Cost effectiveness for PM10-2.5 fell within the following range: \$195,472 to \$843,143 per ton PM10 reduced. The average cost effectiveness used in AirControlNET for PM10-2.5 is \$727,689.14 per ton of PM10-2.5 reduced. All costs are in \$1999.

AT-A-GLANCE TABLE FOR MOBILE SOURCES

Comments:

Status: Demonstrated**Last Reviewed:** 2003

Additional Information:

References:

EPA, 2000: U.S. Environmental Protection Agency, "Regulatory Impact Analysis: Control of Emissions of Air Pollution from Highway Heavy-Duty Engines." EPA420-R-00-010, July 2000.

Pechan, 2003. E.H. Pechan & Associates, Inc., "Methodology to Implement Voluntary Diesel Retrofit Program in AirControlNET," Memo prepared for Tyler Fox of the US EPA, July 2003.

AT-A-GLANCE TABLE FOR MOBILE SOURCES

Source Category: Highway Vehicles - Heavy Duty Diesel Engines

Control Measure Name: Voluntary Diesel Retrofit Program: Diesel Oxidation Catalyst

Rule Name: Not Applicable

Pechan Measure Code: HDR299

POD:

Application: This control measure represents the application of EPA's voluntary diesel retrofit program through the use of the diesel oxidation catalyst as a retrofit technology in 1999. Emissions reduction benefits of CO, VOC, PM10, PM2.5, and SO2 are estimated using EPA's MOBILE6 model and independent research on the percent reductions yielded by this control measure.

This control is applicable to all heavy duty diesel vehicles. Light duty and gasoline-fueled vehicles are not affected by this control.

Affected SCC:

2230070000 Heavy Duty Diesel Vehicles (HDDV), Total: All Road Types

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√				√	√		√	

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: The control efficiencies vary by affected pollutant: PM10 (24.01%); PM2.5 (24.52%); VOC (50%); SO2 (97%); CO (40%)

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: To calculate costs for the use of the diesel oxidation catalyst as a retrofit technology, the assumption was made that all relevant vehicles would be affected by the control. Therefore, all heavy duty diesel vehicles were assumed to employ the diesel oxidation catalyst as a retrofit technology through the voluntary diesel retrofit program. The average cost for diesel oxidation catalysts ranges from \$500 to \$3,000 depending on the engine size, sales volume and whether the installation is a muffler replacement or an in-line installation. For this AirControlNET analysis, the average estimated cost of a diesel oxidation catalyst is \$1,750 per heavy duty diesel vehicle. All costs are in 1999 dollars.

Diesel oxidation catalysts require the use of low sulfur diesel fuel. The costs for the low sulfur diesel fuel were applied to all gallons of diesel fuel used by the heavy duty diesel vehicles. Low sulfur diesel fuel is estimated to cost an additional \$0.05 per gallon of diesel (EPA, 2000). All costs are in 1999 dollars.

Cost Effectiveness: The cost effectiveness of the diesel oxidation catalyst varies greatly by county and depends mostly on the number of vehicles. Cost effectiveness for PM10 fell within the following range: \$48,660 to \$217,612 per ton PM10 reduced. The average cost effectiveness used in AirControlNET for PM10 is \$167,639.74 per ton of PM10 reduced. All costs are in \$1999.

Comments:

AT-A-GLANCE TABLE FOR MOBILE SOURCES

Status: Demonstrated	Last Reviewed: 2003
Additional Information:	

References:

EPA, 2000: U.S. Environmental Protection Agency, "Regulatory Impact Analysis: Control of Emissions of Air Pollution from Highway Heavy-Duty Engines." EPA420-R-00-010, July 2000.

Pechan, 2003. E.H. Pechan & Associates, Inc., "Methodology to Implement Voluntary Diesel Retrofit Program in AirControlNET," Memo prepared for Tyler Fox of the US EPA, July 2003.

AT-A-GLANCE TABLE FOR MOBILE SOURCES

Source Category: Highway Vehicles - Heavy Duty Diesel Engines

Control Measure Name: Voluntary Diesel Retrofit Program: Biodiesel Fuel

Rule Name: Not Applicable

Pechan Measure Code: HDR499

POD:

Application: This control measure represents the application of EPA's voluntary diesel retrofit program through the use of biodiesel fuel as a retrofit activity in 1999. Emissions reduction benefits of CO, VOC, PM10-2.5, and PM2.5 are estimated as a result of research conducted on the percent reductions yielded by this control measure.

This control is applicable to all heavy duty diesel vehicles. Light duty and gasoline-fueled vehicles are not affected by this control.

Affected SCC:

2230070000 Heavy Duty Diesel Vehicles (HDDV), Total: All Road Types

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√				√			√	

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: The control efficiency varies by pollutant: PM10 (7%); PM2.5 (7%); VOC (13%); CO (5%)

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: To calculate costs for the use of biodiesel fuel as a retrofit activity, the assumption was made that all relevant vehicles would be affected by the control. Therefore, the costs of biodiesel fuel is applied to all gallons of fuel used by the heavy duty diesel vehicles. The costs of biodiesel fuel are estimated to range from 15 to 30 cents per gallon. For this AirControlNET analysis, the cost of biodiesel fuel was averaged to \$0.225 per gallon of fuel (Pechan 2003). All costs are in 1999 dollars.

Cost Effectiveness: The cost effectiveness of selective catalytic reduction varies greatly by county and depends mostly on the number of vehicles. Cost effectiveness for PM10 fell within the following range: \$74,033 to \$275,756 per ton PM10 reduced the average control efficiency used in AirControlNET for PM10 is \$209,913.27 per ton of PM10 reduced. All costs are in \$1999.

Comments:

Status: Demonstrated

Last Reviewed: 2003

Additional Information:

References:

Pechan, 2003. E.H. Pechan & Associates, Inc., "Methodology to Implement Voluntary Diesel Retrofit Program in AirControlNET," Memo prepared for Tyler Fox of the US EPA, July 2003.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Industrial Boilers - Coal

Control Measure Name: Fabric Filter (Pulse Jet Type)

Rule Name: Not Applicable

Pechan Measure Code: P2011

POD: 201

Application: This control is the addition of a pulse-jet cleaned fabric filter to reduce PM emissions from waste streams. In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Particulate-laden gas flows into the filter bag from the outside to the inside. The particles collected on the outside drop into a hopper below the fabric filter. During pulse-jet cleaning, a short burst of high pressure air is injected into the bags, dislodging the dust cake.

This control applies to operations with coal-fired boilers.

Affected SCC:

10200101 Anthracite Coal, Pulverized Coal
10200104 Anthracite Coal, Traveling Grate (Overfeed) Stoker
10200201 Industrial, Bituminous/Subbituminous Coal, Pulverized Coal: Wet Bottom
10200202 Industrial, Bituminous/Subbituminous Coal, Pulverized Coal: Dry Bottom
10200203 Industrial, Bituminous/Subbituminous Coal, Cyclone Furnace
10200204 Industrial, Bituminous/Subbituminous Coal, Spreader Stoker
10200205 Industrial, Bituminous/Subbituminous Coal, Overfeed Stoker
10200206 Industrial, Bituminous/Subbituminous Coal, Underfeed Stoker
10200210 Industrial, Bituminous/Subbituminous Coal, Overfeed Stoker **
10200212 Bituminous/Subbituminous Coal, Pulverized Coal: Dry Bottom (Tangential)
10200217 Bituminous/Subbituminous Coal, Atm. Fluidized Bed Combustion-Bubbling (Bituminous)
10200219 Bituminous/Subbituminous Coal, Cogeneration (Bituminous Coal)
10200222 Bituminous/Subbituminous Coal, Pulverized Coal: Dry Bottom (Subbituminous Coal)
10200224 Industrial, Bituminous/Subbituminous Coal, Spreader Stoker (Subbituminous Coal)
10200225 Bituminous/Subbituminous Coal, Traveling Grate (Overfeed) Stoker (Subbituminous)
10200229 Bituminous/Subbituminous Coal, Cogeneration (Subbituminous Coal)
10200303 Lignite, Cyclone Furnace

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 99% from uncontrolled for both PM10 and PM2.5

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs for pulse-jet cleaned systems are generated using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan,2001).

AT-A-GLANCE TABLE FOR POINT SOURCES

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 2000). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$6 to \$26 per scfm
Typical value is \$13 per scfm

O&M Costs:

Range from \$5 to \$24 per scfm
Typical value is \$11 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). O&M costs were calculated for three model plants with flow rates of 25, 75 and 150 thousand acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust loading of 4.0 grains per cubic feet. The operating time was assumed to be 8760 hours per year. An average bag cost was estimated using the costs for standard bag types. Capital recovery for the periodic replacement of bags was included in the O&M cost of the bags using a bag life of 2 years (EPA, 1998a). The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.0671	\$/kW-hr
Compressed air	0.25	\$/1000 scf
Dust disposal	25	\$/ton disposed

Note: All costs are in 1998 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$42 to \$266 per ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$117 per ton PM10 reduced. (1998\$)

Comments:

Status: Demonstrated

Last Reviewed: 2001

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

Particulate composition and emission levels are a complex function of firing configuration, boiler operation, and coal properties.

The cost estimates assume a conventional design under typical operating conditions and do not include auxiliary equipment such as fans and ductwork. The costs for pulse-jet cleaned systems are generated using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a).

Costs are primarily based on volumetric flow rate and the amount of PM in the waste stream. In general, a small unit controlling a low pollutant levels will not be as cost effective as a large unit controlling a high pollutant levels. (EPA, 2000)

Pollutants requiring a high level of control or the fabric filters to be constructed of special materials will increase the costs of the system (EPA, 1998a). The additional costs for controlling complex waste streams are not included in the estimates. For these systems, the capital cost could increase by as much as 75% and the operational and maintenance (O&M) cost could increase by as much as 20% (EPA, 2000).

In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Fabric filters may be in the form of sheets, cartridges, or bags, with many individual filter units together in a group. Bags are the most common type of filter. The dust cake that forms on the filter from the collected PM can significantly increase collection efficiency. (EPA, 2000)

Pulse-jet cleaning of fabric filters is a relatively new type of fabric filter, as they have only been used for the past 30 years. This cleaning mechanism has grown in popularity because it can treat high dust loadings, operate at constant pressure drop, and occupy less space than other types of fabric filters (EPA, 2000). Particulate-laden gas flows into the bag. The gas flows from the outside to the inside of the bags, and then out the gas exhaust. The particles collected on the outside drop into a hopper below the fabric filter (EPA, 1998b).

During pulse-jet cleaning, a short burst of high pressure air is injected into the bags (EPA, 1998b). The pulse is blown through a venturi nozzle at the top of the bags and establishes a shock wave that continues onto the bottom of the bag. The wave flexes the fabric dislodging the dust cake.

There are several unique attributes of pulse-jet cleaning. The cleaning pulse is very brief allowing the flow of dusty gas to continue during cleaning. The bags not being cleaned continue to filter, taking on extra duty from the bags being cleaned (EPA, 2000). Pulse-jet cleaning is more intense and occurs with greater frequency than the other fabric filter cleaning methods. The cleaning dislodges nearly all of the dust cake each time the bag is pulsed. Pulse-jet filters, as a result, do not rely on a dust cake to provide filtration. Felted (non-woven) fabrics are used in these types of filters because they do not require a dust cake. Also it has been found that woven fabrics used with pulse-jet cleaning leak dust after they are cleaned (EPA, 1998b).

Since bags cleaned by the pulse-jet method do not need to be isolated for cleaning, pulsejet cleaned fabric filters do not need extra compartments to maintain adequate filtration during cleaning. Also, because of the intense and frequent nature of the cleaning, they can treat higher gas flow rates with higher dust loadings. Consequently, fabric filters cleaned by the pulse-jet method can be smaller than other filters in the treatment of the same amount of gas and dust, making higher gas-to-cloth ratios achievable (EPA, 1998b).

Fabric filters are useful for collecting particles with resistivities either too low or too high for collection

AT-A-GLANCE TABLE FOR POINT SOURCES

with electrostatic precipitators. Fabric filters are useful in controlling particulate matter less than or equal to 10 micrometers (μm) in diameter (PM10) and particulate matter less than or equal to 2.5 μm in diameter (PM2.5). Fabric filters may be good candidates for collecting fly ash from low-sulfur coals or containing high unburned carbon levels and are relatively difficult to collect with electrostatic precipitators. (EPA, 2000)

References:

EPA, 1998a: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, Chapter 5, EPA 453/B-96-001, Research Triangle Park, NC. December 1998.

EPA, 1998b: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

EPA, 2000: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Fabric Filter - Pulse-Jet Cleaned Type," April 2000.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Industrial Boilers - Coal

Control Measure Name: Dry ESP-Wire Plate Type

Rule Name: Not Applicable

Pechan Measure Code: P2012

POD: 201

Application: This control is the use of dry electrostatic precipitators (ESP) to reduce PM emissions. An ESP uses electrical forces to move particles in an exhaust stream onto collector plates. Electrodes in the center of the flow are maintained at high voltage and generate an electrical field forcing particles to the collector walls. In dry ESPs, the collectors are knocked by various mechanical means to dislodge the particulate, which slides downward into a hopper.

This control applies to all coal-fired industrial boilers.

Affected SCC:

10200101 Anthracite Coal, Pulverized Coal
10200104 Anthracite Coal, Traveling Grate (Overfeed) Stoker
10200201 Industrial, Bituminous/Subbituminous Coal, Pulverized Coal: Wet Bottom
10200202 Industrial, Bituminous/Subbituminous Coal, Pulverized Coal: Dry Bottom
10200203 Industrial, Bituminous/Subbituminous Coal, Cyclone Furnace
10200204 Industrial, Bituminous/Subbituminous Coal, Spreader Stoker
10200205 Industrial, Bituminous/Subbituminous Coal, Overfeed Stoker
10200206 Industrial, Bituminous/Subbituminous Coal, Underfeed Stoker
10200210 Industrial, Bituminous/Subbituminous Coal, Overfeed Stoker **
10200212 Bituminous/Subbituminous Coal, Pulverized Coal: Dry Bottom (Tangential)
10200219 Bituminous/Subbituminous Coal, Cogeneration (Bituminous Coal)
10200222 Bituminous/Subbituminous Coal, Pulverized Coal: Dry Bottom (Subbituminous Coal)
10200224 Industrial, Bituminous/Subbituminous Coal, Spreader Stoker (Subbituminous Coal)
10200225 Bituminous/Subbituminous Coal, Traveling Grate (Overfeed) Stoker (Subbituminous)
10200229 Bituminous/Subbituminous Coal, Cogeneration (Subbituminous Coal)
10200303 Lignite, Cyclone Furnace

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: PM10 control efficiency is 98% from uncontrolled; PM2.5 control efficiency is 95% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs for ESPs of conventional design under typical operating conditions are developed using EPA cost estimating spreadsheets (EPA, 1996). When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan, 2001).

AT-A-GLANCE TABLE FOR POINT SOURCES

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 1999). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$15 to \$50 per scfm
Typical value is \$27 per scfm

O&M Costs:

Range from \$4 to \$40 per scfm
Typical value is \$16 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for ESP (EPA, 1996). O&M costs were calculated for three model plants with flow rates of 200 and 500 thousand acfm and 1 million acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust loading of 6.0 grains per cubic feet. The operating time was assumed to be 8640 hours per year. The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.067	\$/kW-hr
Dust disposal	25	\$/ton disposed

Note: All costs are in 1995 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$40 to \$250 per ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$110 per ton PM10 reduced. (1995\$)

Comments:

Status: Demonstrated	Last Reviewed: 2001
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AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

There are two major coal combustion techniques in industrial boilers - suspension firing and grate firing. Suspension firing is the primary combustion mechanism in pulverized-coal-fired and cyclone-fired units and overfeed stoker-fired units. Both mechanisms are employed in spreader stokers. Pulverized-coal and cyclone furnaces are used primarily in utility and large industrial boilers.

Stokers constitute the most practical method of firing coal for small industrial units. In spreader stokers, a flipping mechanism throws the coal into the furnace and onto a moving fuel bed. Combustion occurs partly in suspension and partly on the grate. In overfeed stokers, coal is fed onto a traveling bed or vibrating grate, and it burns on the fuel bed as it progresses through the furnace (AWMA, 1992).

In the wire-plate ESP, the gas flows around vertical, metal plates. The electrodes are long, weighted wires hanging between the plates. The voltage applied to the electrodes causes the gas between the electrodes to break down, known as a "corona." The electrodes are most often given a negative polarity because a negative corona supports a higher voltage than a positive corona.

Certain types of losses affect control efficiency. The dislodging of the accumulated layer also projects some of the particles back into the gas stream. These particles are processed in later sections of the ESP, but the particles from the last section have no chance to be recaptured. Due to the space needed at the top of the ESP for nonelectrified components, part of the stream may flow around the charged zones. This is called "sneakage" and places an upper limit on the collection efficiency of the ESP. Anti-sneakage baffles are used to force the sneakage flow to mix with the main gas stream for collection in later sections (EPA, 1998).

Another factor in the performance of ESPs is the resistivity of the collected material. All the ion current must pass through the collected layer to reach the ground plates. This creates an electric field in the layer, and it can become large enough to cause electrical breakdown. When this occurs, new ions of the wrong polarity are injected into the wire-plate gap reducing the charge on the particles, which may cause sparking. This condition is called "back corona." When this happens the collection ability of the unit is reduced. At low resistivities the particles are held on the plates so loosely that reentrainment levels are much higher. Hence, care must be taken in measuring or estimating resistivity because it is strongly affected by such variables as temperature, moisture, gas composition, particle composition, and surface characteristics (EPA, 1999).

Dusts with high resistivities are also not well-suited for collection in dry ESPs. These particles are not easily charged nor easily collected. High-resistivity particles form ash layers with very high voltage gradients on the collecting electrodes lead to back corona, reducing the charge on particles and lowering collection efficiency. Fly ash from the combustion of low-sulfur coal typically has a high resistivity, and thus is difficult to collect using dry ESPs (EPA, 1999).

References:

AWMA, 1992: Air & Waste Management Association, "Air Pollution Engineering Manual," edited by A. Buonicore and W. Davis, Van Nostrand Reinhold, NY, NY, 1992.

EPA, 1996: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, EPA 453/B-96-001, Research Triangle Park, NC. February 1996.

EPA, 1998: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

AT-A-GLANCE TABLE FOR POINT SOURCES

EPA, 1999: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Dry Electrostatic Precipitator (ESP) - Wire-Plate Type," May 1999.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Industrial Boilers - Coal

Control Measure Name: Fabric Filter (Reverse-Air Cleaned Type)

Rule Name: Not Applicable

Pechan Measure Code: P2013

POD: 201

Application: This control is the use of a reverse-air cleaned fabric filter to reduce PM emissions from waste streams. In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Reverse-air cleaning is performed by forcing clean air through the filters in the opposite direction of the dusty gas flow. The change in direction of the gas flow causes the bag to flex and crack the filter cake allowing for internal cake collection.

This control applies to operations with coal-fired boilers.

Affected SCC:

10200101 Anthracite Coal, Pulverized Coal
10200104 Anthracite Coal, Traveling Grate (Overfeed) Stoker
10200201 Industrial, Bituminous/Subbituminous Coal, Pulverized Coal: Wet Bottom
10200202 Industrial, Bituminous/Subbituminous Coal, Pulverized Coal: Dry Bottom
10200203 Industrial, Bituminous/Subbituminous Coal, Cyclone Furnace
10200204 Industrial, Bituminous/Subbituminous Coal, Spreader Stoker
10200205 Industrial, Bituminous/Subbituminous Coal, Overfeed Stoker
10200206 Industrial, Bituminous/Subbituminous Coal, Underfeed Stoker
10200210 Industrial, Bituminous/Subbituminous Coal, Overfeed Stoker **
10200212 Bituminous/Subbituminous Coal, Pulverized Coal: Dry Bottom (Tangential)
10200217 Bituminous/Subbituminous Coal, Atm. Fluidized Bed Combustion-Bubbling (Bituminous)
10200219 Bituminous/Subbituminous Coal, Cogeneration (Bituminous Coal)
10200222 Bituminous/Subbituminous Coal, Pulverized Coal: Dry Bottom (Subbituminous Coal)
10200224 Industrial, Bituminous/Subbituminous Coal, Spreader Stoker (Subbituminous Coal)
10200225 Bituminous/Subbituminous Coal, Traveling Grate (Overfeed) Stoker (Subbituminous)
10200229 Bituminous/Subbituminous Coal, Cogeneration (Subbituminous Coal)
10200303 Lignite, Cyclone Furnace

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 99% from uncontrolled for both PM10 and PM2.5

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs for reverse-air cleaned systems are generated using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan,2001).

AT-A-GLANCE TABLE FOR POINT SOURCES

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 2000). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$9 to \$84 per scfm
Typical value is \$34 per scfm

O&M Costs:

Range from \$6 to \$27 per scfm
Typical value is \$13 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). O&M costs were calculated for three model plants with flow rates of 25, 75 and 150 thousand acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust loading of 4.0 grains per cubic feet. The operating time was assumed to be 8760 hours per year. An average bag cost was estimated using the costs for standard bag types. Capital recovery for the periodic replacement of bags was included in the O&M cost of the bags using a bag life of 2 years (EPA, 1998a). The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.0671	\$/kW-hr
Compressed air	0.25	\$/1000 scf
Dust disposal	25	\$/ton disposed

Note: All costs are in 1998 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$53 to \$337 per ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$148 per ton PM10 reduced. (1998\$)

Comments:

Status: Demonstrated	Last Reviewed: 2001
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AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

There are two major coal combustion techniques in industrial boilers - suspension firing and grate firing. Suspension firing is the primary combustion mechanism in pulverized-coal-fired and cyclone-fired units and overfeed stoker-fired units. Both mechanisms are employed in spreader stokers. Pulverized-coal and cyclone furnaces are used primarily in utility and large industrial boilers.

Stokers constitute the most practical method of firing coal for small industrial units. In spreader stokers, a flipping mechanism throws the coal into the furnace and onto a moving fuel bed. Combustion occurs partly in suspension and partly on the grate. In overfeed stokers, coal is fed onto a traveling bed or vibrating grate, and it burns on the fuel bed as it progresses through the furnace (AWMA, 1992).

The cost estimates assume a conventional design under typical operating conditions. The costs do not include any auxiliary equipment (EPA, 2000).

The capital cost for the reverse-jet cleaned fabric baghouse is based on information provided by a manufacturer (EPA, 2000). The capital cost includes only the purchased equipment cost.

Costs are primarily based on volumetric flow rate and the amount of PM in the waste stream. In general, a small unit controlling a low pollutant levels will not be as cost effective as a large unit controlling a high pollutant levels. (EPA, 2000)

Pollutants requiring a high level of control or the fabric filters to be constructed of special materials will increase the costs of the system (EPA, 1998a). The additional costs for controlling complex streams are not reflected in the estimates. For these systems, the capital cost could increase by as much as 40% and the O&M cost could increase by as much as 5%. (EPA, 2000)

In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Fabric filters may be in the form of sheets, cartridges, or bags, with many individual filter units together in a group. Bags are the most common type of filter. The dust cake that forms on the filter from the collected PM can significantly increase collection efficiency. (EPA, 2000)

Reverse-air cleaning is a popular filter cleaning method as it has been used extensively and improved over the years. It is a gentler but sometimes less effective clearing mechanism than mechanical shaking. Reverse-air cleaning is performed by forcing clean air through the filters in the opposite direction of the dusty gas flow. The change in direction of the gas flow causes the bag to flex and crack the filter cake allowing for internal cake collection (EPA, 2000).

The most common design is to have separate compartments within the fabric filter so that each can be isolated and cleaned separately while the others continue to treat the dusty gas. There are several methods of reversing the flow through the filters. One method of providing the reverse flow is by the use of a fan or cleaned gas from other compartments. Reverse-air cleaning only used alone in cases where the dust releases easily from the fabric. In many instances, reverse-air is used along with shaking, pulsing or sonic horns (EPA, 1998b).

Fabric filters are useful for collecting particles with resistivities either too low or too high for collection with electrostatic precipitators. Fabric filters are useful in controlling particulate matter less than or equal to 10 micrometers (μm) in diameter (PM₁₀) and particulate matter less than or equal to 2.5 μm in diameter (PM_{2.5}). Fabric filters may be good candidates for collecting fly ash from low-sulfur coals or containing high unburned carbon levels and are relatively difficult to collect with electrostatic precipitators. (EPA, 2000)

AT-A-GLANCE TABLE FOR POINT SOURCES

References:

AWMA, 1992: Air & Waste Management Association, "Air Pollution Engineering Manual," edited by A. Buonicore and W. Davis, Van Nostrand Reinhold, NY, NY, 1992.

EPA, 1998b: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter, EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

EPA, 1998a: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, Chapter 5, EPA 453/B-96-001, Research Triangle Park, NC. December 1998.

EPA, 2000: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Fabric Filter - Reverse-Air Cleaned Type," April 2000.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Industrial Boilers - Coal

Control Measure Name: Venturi Scrubber

Rule Name: Not Applicable

Pechan Measure Code: P2014

POD: 201

Application: The control is the use of a venturi scrubber to reduce PM emissions. A scrubber is a type of technology that removes air pollutants by inertial and diffusional interception. A venturi scrubber accelerates the waste gas stream to atomize the scrubbing liquid and to improve gas-liquid contact.

This control applies to operations with coal-fired boilers.

Affected SCC:

10200101 Anthracite Coal, Pulverized Coal
10200104 Anthracite Coal, Traveling Grate (Overfeed) Stoker
10200201 Industrial, Bituminous/Subbituminous Coal, Pulverized Coal: Wet Bottom
10200202 Industrial, Bituminous/Subbituminous Coal, Pulverized Coal: Dry Bottom
10200203 Industrial, Bituminous/Subbituminous Coal, Cyclone Furnace
10200204 Industrial, Bituminous/Subbituminous Coal, Spreader Stoker
10200205 Industrial, Bituminous/Subbituminous Coal, Overfeed Stoker
10200206 Industrial, Bituminous/Subbituminous Coal, Underfeed Stoker
10200210 Industrial, Bituminous/Subbituminous Coal, Overfeed Stoker **
10200212 Bituminous/Subbituminous Coal, Pulverized Coal: Dry Bottom (Tangential)
10200219 Bituminous/Subbituminous Coal, Cogeneration (Bituminous Coal)
10200222 Bituminous/Subbituminous Coal, Pulverized Coal: Dry Bottom (Subbituminous Coal)
10200224 Industrial, Bituminous/Subbituminous Coal, Spreader Stoker (Subbituminous Coal)
10200225 Bituminous/Subbituminous Coal, Traveling Grate (Overfeed) Stoker (Subbituminous)
10200229 Bituminous/Subbituminous Coal, Cogeneration (Subbituminous Coal)
10200303 Lignite, Cyclone Furnace

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: PM10 control efficiency is 82% from uncontrolled; PM2.5 control efficiency is 50% from uncontrolled

Equipment Life: 10 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The following are cost ranges for venturi wet scrubbers, developed using EPA cost-estimating spreadsheets (EPA, 1996) and referenced to the volumetric flow rate of the waste stream treated. When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan,2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed

AT-A-GLANCE TABLE FOR POINT SOURCES

capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 1999). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (10 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$3 to \$28 per scfm
Typical value is \$11 per scfm

O&M Costs:

Range from \$4 to \$119 per scfm
Typical value is \$42 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for Impingement Plate Scrubbers (EPA, 1996). O&M costs were calculated for two model plants with flow rates of 2,000 and 150,000 acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. The model plants were assumed to have a dust loading of 3.0 grains per cubic feet. The operating time was assumed to be 8760 hours per year. An inlet water flow rate for the scrubber was assumed to be 9.4 lbs/min. The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.067	\$/kW-hr
Process water price	0.20	\$/1000 gal
Dust disposal	25	\$/ton disposed
Wastewater treatment	3.8	\$/ thousand gal treated

Note: All costs are in 1995 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$76 to \$2,100 per ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$751 per ton PM10 reduced. (1995\$)

Comments:

Status: Demonstrated

Last Reviewed: 2001

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

There are two major coal combustion techniques in industrial boilers - suspension firing and grate firing. Suspension firing is the primary combustion mechanism in pulverized-coal-fired and cyclone-fired units and overfeed stoker-fired units. Both mechanisms are employed in spreader stokers. Pulverized-coal and cyclone furnaces are used primarily in utility and large industrial boilers.

Stokers constitute the most practical method of firing coal for small industrial units. In spreader stokers, a flipping mechanism throws the coal into the furnace and onto a moving fuel bed. Combustion occurs partly in suspension and partly on the grate. In overfeed stokers, coal is fed onto a traveling bed or vibrating grate, and it burns on the fuel bed as it progresses through the furnace (AWMA, 1992).

The costs do not include costs for post-treatment or disposal of used solvent or waste. Actual costs can be substantially higher than in the ranges shown for applications which require expensive materials, solvents, or treatment methods (EPA, 1999). As a rule, smaller units controlling a low concentration waste stream will be much more expensive (per unit volumetric flow rate) than a large unit cleaning a high pollutant load flow.

By product coke production is used to manufacture metallurgical coke by heating high-grade bituminous coal (low sulfur and low ash) in an enclosed oven chamber without oxygen. The resulting solid material consists of elemental carbon and any minerals (ash) that were present in the coal blend that did not volatilize during the process. Sources of air emissions consist of coke oven doors, coke oven lids and off-takes, coke oven charging, coke oven pushing, coke oven underfire stack, coke quenching, battery venting, and coke by-product-recovery plants.

A venturi scrubber accelerates the waste gas stream to improve gas-liquid contact. In a venturi scrubber, a "throat" section is built into the duct that forces the gas stream to accelerate (EPA, 1999). As the gas enters the venturi throat, both gas velocity and turbulence increase.

After the throat section, the mixture decelerates, and further impacts occur causing the droplets to agglomerate. Once the particles have been captured by the liquid, the wetted PM and excess liquid are separated from the gas stream through entrainment. This section usually consists of a cyclonic separator and/or a mist eliminator (EPA, 1998; Corbitt, 1990).

For PM applications, wet scrubbers generate waste, either a slurry or wet sludge. This creates the need for both wastewater treatment and solid waste disposal. Initially, the slurry is treated to separate the solid waste from the water (EPA, 1999). The treated water can then be reused or discharged. Once the water is removed, the remaining waste will be in the form of a solid or sludge. If the solid waste is inert and nontoxic, it can generally be land filled. Hazardous wastes will have more stringent procedures for disposal. In some cases, the solid waste may have value and can be sold or recycled (EPA, 1998).

References:

AWMA, 1992: Air & Waste Management Association, "Air Pollution Engineering Manual," edited by A. Buonicore and W. Davis, Van Nostrand Reinhold, NY, NY, 1992.

Corbitt, 1990: "Standard Handbook of Environmental Engineering," edited by Robert A. Corbitt, McGraw-Hill, New York, NY, 1990.

EPA, 1996: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, EPA 453/B-96-001, Research Triangle Park, NC February.

AT-A-GLANCE TABLE FOR POINT SOURCES

EPA, 1998: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

EPA, 1999: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Venturi Scrubber," July 1999.

Heumann, 1997: W. L. Heumann, "Industrial Air Pollution Control Systems," McGraw Hill Publishers, Inc., Washington, D.C., 1997.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

STAPPA/ALAPCO, 1996: State and Territorial Air Pollution Program Administrators and Association of Local Air Pollution Control Officials, "Controlling Particulate Matter Under the Clean Air Act: A Menu of Options," July 1996.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Industrial Boilers - Coal

Control Measure Name: Increased Monitoring Frequency (IMF) of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P3201

POD: 201

Application: This measure is to conduct improved monitoring for PM_{2.5} emissions at stationary sources. Improved monitoring in this case means increasing the monitoring frequency of electrostatic precipitators, scrubbers, and fabric filters from once per day to four times per hour, with no change in monitoring technique.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (Barr and Schaffner) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

102002** Industrial, Bituminous/Subbituminous Coal

102003** Lignite, Pulverized Coal: Dry Bottom

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 6.5% from uncontrolled for both PM₁₀ and PM_{2.5}

Equipment Life: Not applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs included the incremental record keeping and reporting associated with the increased monitoring frequency. Labor rates for 2003 were made that were obtained from the Bureau of Labor Statistics (labor rates include 140 percent overhead). The incremental costs included a one-time cost for development of the improved monitoring and recurring annual burden costs for incremental record keeping, reporting, and certification activities.

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$620 per ton PM reduced (2003\$).

Comments:

Status:

Last Reviewed: 2004

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM_{2.5} Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 2003.

BLS, 2003: Bureau of Labor Statistics, "Employer Costs for Employee Compensation – June 2003," Table 12, page 16, 2003.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Industrial Boilers - Coal

Control Measure Name: CEM Upgrade and Increased Monitoring Frequency of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P4201

POD: 201

Application: This measure examines the impacts of improving the PM monitoring technique at units currently using an ESP, scrubber, or fabric filter. In this improved technique scenario, the monitoring technique is upgraded to a PM continuous emission monitor. This improved monitoring technique also results in an increase to the monitoring frequency because a PM CEMS can make a measurement every 7.5 minutes. The monitoring frequency increases from once per day to eight times per hour.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (see References) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

102002** Industrial, Bituminous/Subbituminous Coal

102003** Lignite, Pulverized Coal: Dry Bottom

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 7.7% for both PM10 and PM2.5

Equipment Life: Unknown

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The total capital and annual operating costs for implementing an improved monitoring technique are calculated based on data from the EPA CEMS Cost Model and the PM CEMS Knowledge document. Labor rates in the EPA CEMS Cost Model are scaled to reflect 2003 labor rates (including 140 percent overhead) provided by the Bureau of Labor Statistics.

The cost effectiveness at a percent excess emission rate of 0.46 percent is \$5,200 per ton of PM2.5. This is based on a \$34 million capital investment cost, and a \$14 million total annualized cost when applied to 128 facilities.

Note: All costs are in 2003 dollars.

AT-A-GLANCE TABLE FOR POINT SOURCES

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$5,200 per ton PM reduced (2003\$).

Comments:

Status:

Last Reviewed: 2004

Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM_{2.5} Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 8, 2003.

EPA CEMS Cost Model, Version 3.0, U.S. Environmental Protection Agency.

EPA, 2000: U.S. Environmental Protection Agency, "Current Knowledge of Particulate Matter (PM) Continuous Emissions Monitoring," Chapter 9, PM CEMS Cost, September 8, 2000.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Industrial Boilers - Coke

Control Measure Name: Increased Monitoring Frequency (IMF) of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P3241

POD: 241

Application: This measure is to conduct improved monitoring for PM_{2.5} emissions at stationary sources. Improved monitoring in this case means increasing the monitoring frequency of electrostatic precipitators, scrubbers, and fabric filters from once per day to four times per hour, with no change in monitoring technique.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (Barr and Schaffner) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

102008** Industrial, Coke

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 6.5% for both PM₁₀ and PM_{2.5}

Equipment Life: Not applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs included the incremental record keeping and reporting associated with the increased monitoring frequency. Labor rates for 2003 were made that were obtained from the Bureau of Labor Statistics (labor rates include 140 percent overhead). The incremental costs included a one-time cost for development of the improved monitoring and recurring annual burden costs for incremental record keeping, reporting, and certification activities.

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$620 per ton PM reduced (2003\$).

Comments:

Status:

Last Reviewed: 2004

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM2.5 Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 2003.

BLS, 2003: Bureau of Labor Statistics, "Employer Costs for Employee Compensation – June 2003," Table 12, page 16, 2003.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Industrial Boilers - Coke

Control Measure Name: CEM Upgrade and Increased Monitoring Frequency of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P4241

POD: 241

Application: This measure examines the impacts of improving the PM monitoring technique at units currently using an ESP, scrubber, or fabric filter. In this improved technique scenario, the monitoring technique is upgraded to a PM continuous emission monitor. This improved monitoring technique also results in an increase to the monitoring frequency because a PM CEMS can make a measurement every 7.5 minutes. The monitoring frequency increases from once per day to eight times per hour.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (see References) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

102008** Industrial, Coke

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 7.7% for both PM10 and PM2.5

Equipment Life: Unknown

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The total capital and annual operating costs for implementing an improved monitoring technique are calculated based on data from the EPA CEMS Cost Model and the PM CEMS Knowledge document. Labor rates in the EPA CEMS Cost Model are scaled to reflect 2003 labor rates (including 140 percent overhead) provided by the Bureau of Labor Statistics.

The cost effectiveness at a percent excess emission rate of 0.46 percent is \$5,200 per ton of PM2.5. This is based on a \$34 million capital investment cost, and a \$14 million total annualized cost when applied to 128 facilities.

Note: All costs are in 2003 dollars.

AT-A-GLANCE TABLE FOR POINT SOURCES

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$5,200 per ton PM reduced (2003\$).

Comments:

Status:

Last Reviewed: 2004

Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM_{2.5} Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 8, 2003.

EPA CEMS Cost Model, Version 3.0, U.S. Environmental Protection Agency.

EPA, 2000: U.S. Environmental Protection Agency, "Current Knowledge of Particulate Matter (PM) Continuous Emissions Monitoring," Chapter 9, PM CEMS Cost, September 8, 2000.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Industrial Boilers - Liquid Waste

Control Measure Name: Dry ESP-Wire Plate Type

Rule Name: Not Applicable

Pechan Measure Code: P2041

POD: 204

Application: This control is the use of dry electrostatic precipitators (ESP) to reduce PM emissions. An ESP uses electrical forces to move particles in an exhaust stream onto collector plates. Electrodes in the center of the flow are maintained at high voltage and generate an electrical field forcing particles to the collector walls. In dry ESPs, the collectors are knocked by various mechanical means to dislodge the particulate, which slides downward into a hopper.

This control applies operations that have industrial boilers fired with liquid waste, including waste oil.

Affected SCC:

10201301 Industrial, Liquid Waste, Specify Waste Material in Comments

10201302 Industrial, Liquid Waste, Waste Oil

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: PM10 control efficiency is 98% from uncontrolled; PM2.5 control efficiency is 95% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs for ESPs of conventional design under typical operating conditions are developed using EPA cost estimating spreadsheets (EPA, 1996). When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan, 2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 1999). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of

AT-A-GLANCE TABLE FOR POINT SOURCES

equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$15 to \$50 per scfm
Typical value is \$27 per scfm

O&M Costs:

Range from \$4 to \$40 per scfm
Typical value is \$16 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for ESP (EPA, 1996). O&M costs were calculated for three model plants with flow rates of 200 and 500 thousand acfm and 1 million acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust loading of 6.0 grains per cubic feet. The operating time was assumed to be 8640 hours per year. The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.067	\$/kW-hr
Dust disposal	25	\$/ton disposed

Note: All costs are in 1995 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$40 to \$250 per ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$110 per ton PM10 reduced. (1995\$)

Comments:

Status: Demonstrated	Last Reviewed: 2001
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Additional Information:

ESPs are used when control efficiencies of 95 percent or more are required. In the wire-plate ESP, the gas flows around vertical, metal plates. The electrodes are long, weighted wires hanging between the plates. The voltage applied to the electrodes causes the gas between the electrodes to break down, known as a "corona." The electrodes are most often given a negative polarity because a negative corona supports a higher voltage than a positive corona.

Certain types of losses affect control efficiency. The dislodging of the accumulated layer also projects some of the particles back into the gas stream. These particles are processed in later sections of the ESP, but the particles from the last section have no chance to be recaptured. Due to the space needed at the top of the ESP for nonelectrified components, part of the stream may flow around the charged zones. This is called "sneakage" and places an upper limit on the collection efficiency of the ESP. Anti-sneakage baffles are used to force the sneakage flow to mix with the main gas stream for collection in later sections (EPA, 1998).

Another factor in the performance of ESPs is the resistivity of the collected material. All the ion

AT-A-GLANCE TABLE FOR POINT SOURCES

current must pass through the collected layer to reach the ground plates. This creates an electric field in the layer, and it can become large enough to cause electrical breakdown. When this occurs, new ions of the wrong polarity are injected into the wire-plate gap reducing the charge on the particles, which may cause sparking. This condition is called "back corona." When this happens the collection ability of the unit is reduced. At low resistivities the particles are held on the plates so loosely that reentrainment levels are much higher. Hence, care must be taken in measuring or estimating resistivity because it is strongly affected by such variables as temperature, moisture, gas composition, particle composition, and surface characteristics (EPA, 1999).

Dusts with high resistivities are also not well-suited for collection in dry ESPs. These particles are not easily charged nor easily collected. High-resistivity particles form ash layers with very high voltage gradients on the collecting electrodes lead to back corona, reducing the charge on particles and lowering collection efficiency. Fly ash from the combustion of low-sulfur coal typically has a high resistivity, and thus is difficult to collect using dry ESPs (EPA, 1999).

References:

EPA, 1996: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, EPA 453/B-96-001, Research Triangle Park, NC. February 1996.

EPA, 1998: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

EPA, 1999: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Dry Electrostatic Precipitator (ESP) - Wire-Plate Type," May 1999.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Industrial Boilers - Liquid Waste

Control Measure Name: Increased Monitoring Frequency (IMF) of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P3204

POD: 204

Application: This measure is to conduct improved monitoring for PM_{2.5} emissions at stationary sources. Improved monitoring in this case means increasing the monitoring frequency of electrostatic precipitators, scrubbers, and fabric filters from once per day to four times per hour, with no change in monitoring technique.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (Barr and Schaffner) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

102013** Industrial, Liquid Waste

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 6.5% for both PM₁₀ and PM_{2.5}

Equipment Life: Not applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs included the incremental record keeping and reporting associated with the increased monitoring frequency. Labor rates for 2003 were made that were obtained from the Bureau of Labor Statistics (labor rates include 140 percent overhead). The incremental costs included a one-time cost for development of the improved monitoring and recurring annual burden costs for incremental record keeping, reporting, and certification activities.

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$620 per ton PM reduced (2003\$).

Comments:

Status:

Last Reviewed: 2004

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM2.5 Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 2003.

BLS, 2003: Bureau of Labor Statistics, "Employer Costs for Employee Compensation – June 2003," Table 12, page 16, 2003.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Industrial Boilers - Liquid Waste

Control Measure Name: CEM Upgrade and Increased Monitoring Frequency of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P4204

POD: 204

Application: This measure examines the impacts of improving the PM monitoring technique at units currently using an ESP, scrubber, or fabric filter. In this improved technique scenario, the monitoring technique is upgraded to a PM continuous emission monitor. This improved monitoring technique also results in an increase to the monitoring frequency because a PM CEMS can make a measurement every 7.5 minutes. The monitoring frequency increases from once per day to eight times per hour.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (see References) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

102013** Industrial, Liquid Waste

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 7.7% for both PM10 and PM2.5

Equipment Life: Unknown

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The total capital and annual operating costs for implementing an improved monitoring technique are calculated based on data from the EPA CEMS Cost Model and the PM CEMS Knowledge document. Labor rates in the EPA CEMS Cost Model are scaled to reflect 2003 labor rates (including 140 percent overhead) provided by the Bureau of Labor Statistics.

The cost effectiveness at a percent excess emission rate of 0.46 percent is \$5,200 per ton of PM2.5. This is based on a \$34 million capital investment cost, and a \$14 million total annualized cost when applied to 128 facilities.

Note: All costs are in 2003 dollars.

AT-A-GLANCE TABLE FOR POINT SOURCES

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$5,200 per ton PM reduced (2003\$).

Comments:

Status:

Last Reviewed: 2004

Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM_{2.5} Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 8, 2003.

EPA CEMS Cost Model, Version 3.0, U.S. Environmental Protection Agency.

EPA, 2000: U.S. Environmental Protection Agency, "Current Knowledge of Particulate Matter (PM) Continuous Emissions Monitoring," Chapter 9, PM CEMS Cost, September 8, 2000.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Industrial Boilers - LPG

Control Measure Name: Increased Monitoring Frequency (IMF) of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P3242

POD: 242

Application: This measure is to conduct improved monitoring for PM_{2.5} emissions at stationary sources. Improved monitoring in this case means increasing the monitoring frequency of electrostatic precipitators, scrubbers, and fabric filters from once per day to four times per hour, with no change in monitoring technique.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (Barr and Schaffner) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

102010** Industrial, Liquified Petroleum Gas (LPG)

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 6.5% for both PM₁₀ and PM_{2.5}

Equipment Life: Not applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs included the incremental record keeping and reporting associated with the increased monitoring frequency. Labor rates for 2003 were made that were obtained from the Bureau of Labor Statistics (labor rates include 140 percent overhead). The incremental costs included a one-time cost for development of the improved monitoring and recurring annual burden costs for incremental record keeping, reporting, and certification activities.

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$620 per ton PM reduced (2003\$).

Comments:

Status:

Last Reviewed: 2004

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM_{2.5} Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 2003.

BLS, 2003: Bureau of Labor Statistics, "Employer Costs for Employee Compensation – June 2003," Table 12, page 16, 2003.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Industrial Boilers - LPG

Control Measure Name: CEM Upgrade and Increased Monitoring Frequency of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P4242

POD: 242

Application: This measure examines the impacts of improving the PM monitoring technique at units currently using an ESP, scrubber, or fabric filter. In this improved technique scenario, the monitoring technique is upgraded to a PM continuous emission monitor. This improved monitoring technique also results in an increase to the monitoring frequency because a PM CEMS can make a measurement every 7.5 minutes. The monitoring frequency increases from once per day to eight times per hour.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (see References) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

102010** Industrial, Liquified Petroleum Gas (LPG)

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 7.7% for both PM10 and PM2.5

Equipment Life: Unknown

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The total capital and annual operating costs for implementing an improved monitoring technique are calculated based on data from the EPA CEMS Cost Model and the PM CEMS Knowledge document. Labor rates in the EPA CEMS Cost Model are scaled to reflect 2003 labor rates (including 140 percent overhead) provided by the Bureau of Labor Statistics.

The cost effectiveness at a percent excess emission rate of 0.46 percent is \$5,200 per ton of PM2.5. This is based on a \$34 million capital investment cost, and a \$14 million total annualized cost when applied to 128 facilities.

Note: All costs are in 2003 dollars.

AT-A-GLANCE TABLE FOR POINT SOURCES

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$5,200 per ton PM reduced (2003\$).

Comments:

Status:

Last Reviewed: 2004

Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM_{2.5} Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 8, 2003.

EPA CEMS Cost Model, Version 3.0, U.S. Environmental Protection Agency.

EPA, 2000: U.S. Environmental Protection Agency, "Current Knowledge of Particulate Matter (PM) Continuous Emissions Monitoring," Chapter 9, PM CEMS Cost, September 8, 2000.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Industrial Boilers - Natural Gas

Control Measure Name: Increased Monitoring Frequency (IMF) of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P3243

POD: 243

Application: This measure is to conduct improved monitoring for PM_{2.5} emissions at stationary sources. Improved monitoring in this case means increasing the monitoring frequency of electrostatic precipitators, scrubbers, and fabric filters from once per day to four times per hour, with no change in monitoring technique.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (Barr and Schaffner) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

102006** Industrial, Natural Gas

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 6.5% for both PM₁₀ and PM_{2.5}

Equipment Life: Not applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs included the incremental record keeping and reporting associated with the increased monitoring frequency. Labor rates for 2003 were made that were obtained from the Bureau of Labor Statistics (labor rates include 140 percent overhead). The incremental costs included a one-time cost for development of the improved monitoring and recurring annual burden costs for incremental record keeping, reporting, and certification activities.

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$620 per ton PM reduced (2003\$).

Comments:

Status:

Last Reviewed: 2004

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM_{2.5} Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 2003.

BLS, 2003: Bureau of Labor Statistics, "Employer Costs for Employee Compensation – June 2003," Table 12, page 16, 2003.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Industrial Boilers - Natural Gas

Control Measure Name: CEM Upgrade and Increased Monitoring Frequency of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P4243

POD: 243

Application: This measure examines the impacts of improving the PM monitoring technique at units currently using an ESP, scrubber, or fabric filter. In this improved technique scenario, the monitoring technique is upgraded to a PM continuous emission monitor. This improved monitoring technique also results in an increase to the monitoring frequency because a PM CEMS can make a measurement every 7.5 minutes. The monitoring frequency increases from once per day to eight times per hour.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (see References) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

102006** Industrial, Natural Gas

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 7.7% for both PM10 and PM2.5

Equipment Life: Unknown

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The total capital and annual operating costs for implementing an improved monitoring technique are calculated based on data from the EPA CEMS Cost Model and the PM CEMS Knowledge document. Labor rates in the EPA CEMS Cost Model are scaled to reflect 2003 labor rates (including 140 percent overhead) provided by the Bureau of Labor Statistics.

The cost effectiveness at a percent excess emission rate of 0.46 percent is \$5,200 per ton of PM2.5. This is based on a \$34 million capital investment cost, and a \$14 million total annualized cost when applied to 128 facilities.

Note: All costs are in 2003 dollars.

AT-A-GLANCE TABLE FOR POINT SOURCES

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$5,200 per ton PM reduced (2003\$).

Comments:

Status:

Last Reviewed: 2004

Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM_{2.5} Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 8, 2003.

EPA CEMS Cost Model, Version 3.0, U.S. Environmental Protection Agency.

EPA, 2000: U.S. Environmental Protection Agency, "Current Knowledge of Particulate Matter (PM) Continuous Emissions Monitoring," Chapter 9, PM CEMS Cost, September 8, 2000.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Industrial Boilers - Oil

Control Measure Name: Dry ESP-Wire Plate Type

Rule Name: Not Applicable

Pechan Measure Code: P2031

POD: 203

Application: This control is the use of dry electrostatic precipitators (ESP) to reduce PM emissions. An ESP uses electrical forces to move particles in an exhaust stream onto collector plates. Electrodes in the center of the flow are maintained at high voltage and generate an electrical field forcing particles to the collector walls. In dry ESPs, the collectors are knocked by various mechanical means to dislodge the particulate, which slides downward into a hopper.

This control applies to operations with oil-fired boilers.

Affected SCC:

10200401 Industrial, Residual Oil, Grade 6 Oil
10200402 Residual Oil, 10-100 Million Btu/hr **
10200404 Industrial, Residual Oil, Grade 5 Oil
10200405 Residual Oil, Cogeneration
10200501 Industrial, Distillate Oil, Grades 1 and 2 Oil
10200504 Industrial, Distillate Oil, Grade 4 Oil

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: PM10 control efficiency is 98% from uncontrolled; PM2.5 control efficiency is 95% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs for ESPs of conventional design under typical operating conditions are developed using EPA cost estimating spreadsheets (EPA, 1996). When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan, 2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 1999). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated

AT-A-GLANCE TABLE FOR POINT SOURCES

spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$15 to \$50 per scfm
Typical value is \$27 per scfm

O&M Costs:

Range from \$4 to \$40 per scfm
Typical value is \$16 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for ESP (EPA, 1996). O&M costs were calculated for three model plants with flow rates of 200 and 500 thousand acfm and 1 million acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust loading of 6.0 grains per cubic feet. The operating time was assumed to be 8640 hours per year. The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.067	\$/kW-hr
Dust disposal	25	\$/ton disposed

Note: All costs are in 1995 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$40 to \$250 per ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$110 per ton PM10 reduced. (1995\$)

Comments:

Status: Demonstrated	Last Reviewed: 2001
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Additional Information:

Heavier fuel oil derived from crude petroleum are referred to as residual oils and are graded from No. 4 (very light residual) to No. 6 (residual). Emissions from fuel oil combustion depend on the grade and composition of the oil, the type and size of the boiler, firing practices used, and the level of equipment maintenance.

In the wire-plate ESP, the gas flows around vertical, metal plates. The electrodes are long, weighted wires hanging between the plates. The voltage applied to the electrodes causes the gas between the electrodes to break down, known as a "corona." The electrodes are most often given a negative polarity because a negative corona supports a higher voltage than a positive corona.

Certain types of losses affect control efficiency. The dislodging of the accumulated layer also projects some of the particles back into the gas stream. These particles are processed in later

AT-A-GLANCE TABLE FOR POINT SOURCES

sections of the ESP, but the particles from the last section have no chance to be recaptured. Due to the space needed at the top of the ESP for nonelectrified components, part of the stream may flow around the charged zones. This is called "sneakage" and places an upper limit on the collection efficiency of the ESP. Anti-sneakage baffles are used to force the sneakage flow to mix with the main gas stream for collection in later sections (EPA, 1998).

Another factor in the performance of ESPs is the resistivity of the collected material. All the ion current must pass through the collected layer to reach the ground plates. This creates an electric field in the layer, and it can become large enough to cause electrical breakdown. When this occurs, new ions of the wrong polarity are injected into the wire-plate gap reducing the charge on the particles, which may cause sparking. This condition is called "back corona." When this happens the collection ability of the unit is reduced. At low resistivities the particles are held on the plates so loosely that reentrainment levels are much higher. Hence, care must be taken in measuring or estimating resistivity because it is strongly affected by such variables as temperature, moisture, gas composition, particle composition, and surface characteristics (EPA, 1999).

Dusts with high resistivities are also not well-suited for collection in dry ESPs. These particles are not easily charged nor easily collected. High-resistivity particles form ash layers with very high voltage gradients on the collecting electrodes lead to back corona, reducing the charge on particles and lowering collection efficiency. Fly ash from the combustion of low-sulfur coal typically has a high resistivity, and thus is difficult to collect using dry ESPs (EPA, 1999).

References:

EPA, 1996: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, EPA 453/B-96-001, Research Triangle Park, NC. February 1996.

EPA, 1998: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

EPA, 1999: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Dry Electrostatic Precipitator (ESP) - Wire-Plate Type," May 1999.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Industrial Boilers - Oil

Control Measure Name: Venturi Scrubber

Rule Name: Not Applicable

Pechan Measure Code: P2032

POD: 203

Application: The control is the use of a venturi scrubber to reduce PM emissions. A scrubber is a type of technology that removes air pollutants by inertial and diffusional interception. A venturi scrubber accelerates the waste gas stream to atomize the scrubbing liquid and to improve gas-liquid contact.

This control applies to operations with oil-fired boilers.

Affected SCC:

10200401 Industrial, Residual Oil, Grade 6 Oil
10200402 Residual Oil, 10-100 Million Btu/hr **
10200404 Industrial, Residual Oil, Grade 5 Oil
10200405 Residual Oil, Cogeneration
10200501 Industrial, Distillate Oil, Grades 1 and 2 Oil
10200504 Industrial, Distillate Oil, Grade 4 Oil

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: PM10 control efficiency is 92% from uncontrolled; PM2.5 control efficiency is 89% from uncontrolled

Equipment Life: 10 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The following are cost ranges for venturi wet scrubbers, developed using EPA cost-estimating spreadsheets (EPA, 1996) and referenced to the volumetric flow rate of the waste stream treated. When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan,2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 1999). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (10 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of

AT-A-GLANCE TABLE FOR POINT SOURCES

equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$3 to \$28 per scfm
Typical value is \$11 per scfm

O&M Costs:

Range from \$4 to \$119 per scfm
Typical value is \$42 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for Impingement Plate Scrubbers (EPA, 1996). O&M costs were calculated for two model plants with flow rates of 2,000 and 150,000 acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. The model plants were assumed to have a dust loading of 3.0 grains per cubic feet. The operating time was assumed to be 8760 hours per year. An inlet water flow rate for the scrubber was assumed to be 9.4 lbs/min. The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.067	\$/kW-hr
Process water price	0.20	\$/1000 gal
Dust disposal	25	\$/ton disposed
Wastewater treatment	3.8	\$/ thousand gal treated

Note: All costs are in 1995 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$76 to \$2,100 per ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$751 per ton PM10 reduced. (1995\$)

Comments:

Status: Demonstrated	Last Reviewed: 2001
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Additional Information:

Fuel-oil types include heavier fuel oil derived from crude petroleum are referred to as residual oils and are graded from No. 4 (very light residual) to No. 6 (residual). Emissions from fuel oil combustion depend on the grade and composition of the oil, the type and size of the boiler, firing practices used, and the level of equipment maintenance.

The costs do not include costs for post-treatment or disposal of used solvent or waste. Actual costs can be substantially higher than in the ranges shown for applications which require expensive materials, solvents, or treatment methods (EPA, 1999). As a rule, smaller units controlling a low concentration waste stream will be much more expensive (per unit volumetric flow rate) than a large unit cleaning a high pollutant load flow.

AT-A-GLANCE TABLE FOR POINT SOURCES

By product coke production is used to manufacture metallurgical coke by heating high-grade bituminous coal (low sulfur and low ash) in an enclosed oven chamber without oxygen. The resulting solid material consists of elemental carbon and any minerals (ash) that were present in the coal blend that did not volatilize during the process. Sources of air emissions consist of coke oven doors, coke oven lids and off-takes, coke oven charging, coke oven pushing, coke oven underfire stack, coke quenching, battery venting, and coke by-product-recovery plants.

A venturi scrubber accelerates the waste gas stream to improve gas-liquid contact. In a venturi scrubber, a "throat" section is built into the duct that forces the gas stream to accelerate (EPA, 1999). As the gas enters the venturi throat, both gas velocity and turbulence increase.

After the throat section, the mixture decelerates, and further impacts occur causing the droplets to agglomerate. Once the particles have been captured by the liquid, the wetted PM and excess liquid are separated from the gas stream through entrainment. This section usually consists of a cyclonic separator and/or a mist eliminator (EPA, 1998; Corbitt, 1990).

For PM applications, wet scrubbers generate waste, either a slurry or wet sludge. This creates the need for both wastewater treatment and solid waste disposal. Initially, the slurry is treated to separate the solid waste from the water (EPA, 1999). The treated water can then be reused or discharged. Once the water is removed, the remaining waste will be in the form of a solid or sludge. If the solid waste is inert and nontoxic, it can generally be land filled. Hazardous wastes will have more stringent procedures for disposal. In some cases, the solid waste may have value and can be sold or recycled (EPA, 1998).

References:

Corbitt, 1990: "Standard Handbook of Environmental Engineering," edited by Robert A. Corbitt, McGraw-Hill, New York, NY, 1990.

EPA, 1996: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, EPA 453/B-96-001, Research Triangle Park, NC February.

EPA, 1998: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

EPA, 1999: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Venturi Scrubber," July 1999.

Heumann, 1997: W. L. Heumann, "Industrial Air Pollution Control Systems," McGraw Hill Publishers, Inc., Washington, D.C., 1997.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

STAPPA/ALAPCO, 1996: State and Territorial Air Pollution Program Administrators and Association of Local Air Pollution Control Officials, "Controlling Particulate Matter Under the Clean Air Act: A Menu of Options," July 1996.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Industrial Boilers - Oil

Control Measure Name: Increased Monitoring Frequency (IMF) of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P3203

POD: 203

Application: This measure is to conduct improved monitoring for PM_{2.5} emissions at stationary sources. Improved monitoring in this case means increasing the monitoring frequency of electrostatic precipitators, scrubbers, and fabric filters from once per day to four times per hour, with no change in monitoring technique.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (Barr and Schaffner) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

102004** Industrial, Residual Oil

102005** Industrial, Distillate Oil

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 6.5% for both PM₁₀ and PM_{2.5}

Equipment Life: Not applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs included the incremental record keeping and reporting associated with the increased monitoring frequency. Labor rates for 2003 were made that were obtained from the Bureau of Labor Statistics (labor rates include 140 percent overhead). The incremental costs included a one-time cost for development of the improved monitoring and recurring annual burden costs for incremental record keeping, reporting, and certification activities.

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$620 per ton PM reduced (2003\$).

Comments:

Status:

Last Reviewed: 2004

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM2.5 Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 2003.

BLS, 2003: Bureau of Labor Statistics, "Employer Costs for Employee Compensation – June 2003," Table 12, page 16, 2003.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Industrial Boilers - Oil

Control Measure Name: CEM Upgrade and Increased Monitoring Frequency of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P4203

POD: 203

Application: This measure examines the impacts of improving the PM monitoring technique at units currently using an ESP, scrubber, or fabric filter. In this improved technique scenario, the monitoring technique is upgraded to a PM continuous emission monitor. This improved monitoring technique also results in an increase to the monitoring frequency because a PM CEMS can make a measurement every 7.5 minutes. The monitoring frequency increases from once per day to eight times per hour.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (see References) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

102004** Industrial, Residual Oil

102005** Industrial, Distillate Oil

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 7.7% for both PM10 and PM2.5

Equipment Life: Unknown

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The total capital and annual operating costs for implementing an improved monitoring technique are calculated based on data from the EPA CEMS Cost Model and the PM CEMS Knowledge document. Labor rates in the EPA CEMS Cost Model are scaled to reflect 2003 labor rates (including 140 percent overhead) provided by the Bureau of Labor Statistics.

The cost effectiveness at a percent excess emission rate of 0.46 percent is \$5,200 per ton of PM2.5. This is based on a \$34 million capital investment cost, and a \$14 million total annualized cost when applied to 128 facilities.

Note: All costs are in 2003 dollars.

AT-A-GLANCE TABLE FOR POINT SOURCES

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$5,200 per ton PM reduced (2003\$).

Comments:

Status:

Last Reviewed: 2004

Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM_{2.5} Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 8, 2003.

EPA CEMS Cost Model, Version 3.0, U.S. Environmental Protection Agency.

EPA, 2000: U.S. Environmental Protection Agency, "Current Knowledge of Particulate Matter (PM) Continuous Emissions Monitoring," Chapter 9, PM CEMS Cost, September 8, 2000.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Industrial Boilers - Process Gas

Control Measure Name: Increased Monitoring Frequency (IMF) of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P3244

POD: 244

Application: This measure is to conduct improved monitoring for PM_{2.5} emissions at stationary sources. Improved monitoring in this case means increasing the monitoring frequency of electrostatic precipitators, scrubbers, and fabric filters from once per day to four times per hour, with no change in monitoring technique.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (Barr and Schaffner) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

102007** Industrial, Process Gas

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 6.5% for both PM₁₀ and PM_{2.5}

Equipment Life: Not applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs included the incremental record keeping and reporting associated with the increased monitoring frequency. Labor rates for 2003 were made that were obtained from the Bureau of Labor Statistics (labor rates include 140 percent overhead). The incremental costs included a one-time cost for development of the improved monitoring and recurring annual burden costs for incremental record keeping, reporting, and certification activities.

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$620 per ton PM reduced (2003\$).

Comments:

Status:

Last Reviewed: 2004

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM_{2.5} Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 2003.

BLS, 2003: Bureau of Labor Statistics, "Employer Costs for Employee Compensation – June 2003," Table 12, page 16, 2003.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Industrial Boilers - Process Gas

Control Measure Name: CEM Upgrade and Increased Monitoring Frequency of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P4244

POD: 244

Application: This measure examines the impacts of improving the PM monitoring technique at units currently using an ESP, scrubber, or fabric filter. In this improved technique scenario, the monitoring technique is upgraded to a PM continuous emission monitor. This improved monitoring technique also results in an increase to the monitoring frequency because a PM CEMS can make a measurement every 7.5 minutes. The monitoring frequency increases from once per day to eight times per hour.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (see References) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

102007** Industrial, Process Gas

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 7.7% for both PM10 and PM2.5

Equipment Life: Unknown

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The total capital and annual operating costs for implementing an improved monitoring technique are calculated based on data from the EPA CEMS Cost Model and the PM CEMS Knowledge document. Labor rates in the EPA CEMS Cost Model are scaled to reflect 2003 labor rates (including 140 percent overhead) provided by the Bureau of Labor Statistics.

The cost effectiveness at a percent excess emission rate of 0.46 percent is \$5,200 per ton of PM2.5. This is based on a \$34 million capital investment cost, and a \$14 million total annualized cost when applied to 128 facilities.

Note: All costs are in 2003 dollars.

AT-A-GLANCE TABLE FOR POINT SOURCES

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$5,200 per ton PM reduced (2003\$).

Comments:

Status:

Last Reviewed: 2004

Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM_{2.5} Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 8, 2003.

EPA CEMS Cost Model, Version 3.0, U.S. Environmental Protection Agency.

EPA, 2000: U.S. Environmental Protection Agency, "Current Knowledge of Particulate Matter (PM) Continuous Emissions Monitoring," Chapter 9, PM CEMS Cost, September 8, 2000.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Industrial Boilers - Solid Waste

Control Measure Name: Increased Monitoring Frequency (IMF) of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P3245

POD: 245

Application: This measure is to conduct improved monitoring for PM_{2.5} emissions at stationary sources. Improved monitoring in this case means increasing the monitoring frequency of electrostatic precipitators, scrubbers, and fabric filters from once per day to four times per hour, with no change in monitoring technique.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (Barr and Schaffner) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

102012** Industrial, Solid Waste

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 6.5% for both PM₁₀ and PM_{2.5}

Equipment Life: Not applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs included the incremental record keeping and reporting associated with the increased monitoring frequency. Labor rates for 2003 were made that were obtained from the Bureau of Labor Statistics (labor rates include 140 percent overhead). The incremental costs included a one-time cost for development of the improved monitoring and recurring annual burden costs for incremental record keeping, reporting, and certification activities.

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$620 per ton PM reduced (2003\$).

Comments:

Status:

Last Reviewed: 2004

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM_{2.5} Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 2003.

BLS, 2003: Bureau of Labor Statistics, "Employer Costs for Employee Compensation – June 2003," Table 12, page 16, 2003.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Industrial Boilers - Solid Waste

Control Measure Name: CEM Upgrade and Increased Monitoring Frequency of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P4245

POD: 245

Application: This measure examines the impacts of improving the PM monitoring technique at units currently using an ESP, scrubber, or fabric filter. In this improved technique scenario, the monitoring technique is upgraded to a PM continuous emission monitor. This improved monitoring technique also results in an increase to the monitoring frequency because a PM CEMS can make a measurement every 7.5 minutes. The monitoring frequency increases from once per day to eight times per hour.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (see References) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

102012** Industrial, Solid Waste

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 7.7% for both PM10 and PM2.5

Equipment Life: Unknown

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The total capital and annual operating costs for implementing an improved monitoring technique are calculated based on data from the EPA CEMS Cost Model and the PM CEMS Knowledge document. Labor rates in the EPA CEMS Cost Model are scaled to reflect 2003 labor rates (including 140 percent overhead) provided by the Bureau of Labor Statistics.

The cost effectiveness at a percent excess emission rate of 0.46 percent is \$5,200 per ton of PM2.5. This is based on a \$34 million capital investment cost, and a \$14 million total annualized cost when applied to 128 facilities.

Note: All costs are in 2003 dollars.

AT-A-GLANCE TABLE FOR POINT SOURCES

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$5,200 per ton PM reduced (2003\$).

Comments:

Status:

Last Reviewed: 2004

Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM_{2.5} Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 8, 2003.

EPA CEMS Cost Model, Version 3.0, U.S. Environmental Protection Agency.

EPA, 2000: U.S. Environmental Protection Agency, "Current Knowledge of Particulate Matter (PM) Continuous Emissions Monitoring," Chapter 9, PM CEMS Cost, September 8, 2000.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Industrial Boilers - Wood

Control Measure Name: Fabric Filter (Pulse Jet Type)

Rule Name: Not Applicable

Pechan Measure Code: P2021

POD: 202

Application: This control is the addition of a pulse-jet cleaned fabric filter to reduce PM emissions from waste streams. In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Particulate-laden gas flows into the filter bag from the outside to the inside. The particles collected on the outside drop into a hopper below the fabric filter. During pulse-jet cleaning, a short burst of high pressure air is injected into the bags, dislodging the dust cake.

This control applies to operations with wood-fired boilers, classified under the following SCCs: 10200901, 10200902, 10200903, 10200904, 10200905, 10200906, 10200907.

Affected SCC:

10200901 Industrial, Wood/Bark Waste, Bark-fired Boiler (> 50,000 Lb Steam)
10200902 Industrial, Wood/Bark Waste, Wood/Bark-fired Boiler (> 50,000 Lb Steam)
10200903 Industrial, Wood/Bark Waste, Wood-fired Boiler (> 50,000 Lb Steam)
10200904 Wood/Bark Waste, Bark-fired Boiler (< 50,000 Lb Steam)
10200905 Wood/Bark Waste, Wood/Bark-fired Boiler (< 50,000 Lb Steam)
10200906 Industrial, Wood/Bark Waste, Wood-fired Boiler (< 50,000 Lb Steam)
10200907 Wood/Bark Waste, Wood Cogeneration

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 99% from uncontrolled for both PM10 and PM2.5

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs for pulse-jet cleaned systems are generated using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan,2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 2000). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets

AT-A-GLANCE TABLE FOR POINT SOURCES

were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$6 to \$26 per scfm
Typical value is \$13 per scfm

O&M Costs:

Range from \$5 to \$24 per scfm
Typical value is \$11 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). O&M costs were calculated for three model plants with flow rates of 25, 75 and 150 thousand acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust loading of 4.0 grains per cubic feet. The operating time was assumed to be 8760 hours per year. An average bag cost was estimated using the costs for standard bag types. Capital recovery for the periodic replacement of bags was included in the O&M cost of the bags using a bag life of 2 years (EPA, 1998a). The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.0671	\$/kW-hr
Compressed air	0.25	\$/1000 scf
Dust disposal	25	\$/ton disposed

Note: All costs are in 1998 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$42 to \$266 per ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$117 per ton PM10 reduced. (1998\$)

Comments:

Status: Demonstrated	Last Reviewed: 2001
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Additional Information:

The burning of wood and bark waste in boilers is mostly confined to industries where wood and bark waste is available as a byproduct. Wood and bark waste is burned to obtain heat energy and to alleviate possible solid waste disposal problems. In boilers, the waste is burned in the form of hogged wood, sawdust, shavings, chips, sander dust, or wood trim. Bark is the major type of waste burned in "power" boilers at pulp and paper mills. At lumber, furniture, and plywood plants, either a mixture of wood and bark waste or wood waste alone is burned most frequently (EPA, 1995).

The cost estimates assume a conventional design under typical operating conditions and do not

AT-A-GLANCE TABLE FOR POINT SOURCES

include auxiliary equipment such as fans and ductwork. The costs for pulse-jet cleaned systems are generated using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a).

Costs are primarily based on volumetric flow rate and the amount of PM in the waste stream. In general, a small unit controlling a low pollutant levels will not be as cost effective as a large unit controlling a high pollutant levels. (EPA, 2000)

Pollutants requiring a high level of control or the fabric filters to be constructed of special materials will increase the costs of the system (EPA, 1998a). The additional costs for controlling complex waste streams are not included in the estimates. For these systems, the capital cost could increase by as much as 75% and the operational and maintenance (O&M) cost could increase by as much as 20% (EPA, 2000).

In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Fabric filters may be in the form of sheets, cartridges, or bags, with many individual filter units together in a group. Bags are the most common type of filter. The dust cake that forms on the filter from the collected PM can significantly increase collection efficiency. (EPA, 2000)

Pulse-jet cleaning of fabric filters is a relatively new type of fabric filter, as they have only been used for the past 30 years. This cleaning mechanism has grown in popularity because it can treat high dust loadings, operate at constant pressure drop, and occupy less space than other types of fabric filters (EPA, 2000). Particulate-laden gas flows into the bag. The gas flows from the outside to the inside of the bags, and then out the gas exhaust. The particles collected on the outside drop into a hopper below the fabric filter (EPA, 1998b).

During pulse-jet cleaning, a short burst of high pressure air is injected into the bags (EPA, 1998b). The pulse is blown through a venturi nozzle at the top of the bags and establishes a shock wave that continues onto the bottom of the bag. The wave flexes the fabric dislodging the dust cake.

There are several unique attributes of pulse-jet cleaning. The cleaning pulse is very brief allowing the flow of dusty gas to continue during cleaning. The bags not being cleaned continue to filter, taking on extra duty from the bags being cleaned (EPA, 2000). Pulse-jet cleaning is more intense and occurs with greater frequency than the other fabric filter cleaning methods. The cleaning dislodges nearly all of the dust cake each time the bag is pulsed. Pulse-jet filters, as a result, do not rely on a dust cake to provide filtration. Felted (non-woven) fabrics are used in these types of filters because they do not require a dust cake. Also it has been found that woven fabrics used with pulse-jet cleaning leak dust after they are cleaned (EPA, 1998b).

Since bags cleaned by the pulse-jet method do not need to be isolated for cleaning, pulsejet cleaned fabric filters do not need extra compartments to maintain adequate filtration during cleaning. Also, because of the intense and frequent nature of the cleaning, they can treat higher gas flow rates with higher dust loadings. Consequently, fabric filters cleaned by the pulse-jet method can be smaller than other filters in the treatment of the same amount of gas and dust, making higher gas-to-cloth ratios achievable (EPA, 1998b).

Fabric filters are useful for collecting particles with resistivities either too low or too high for collection with electrostatic precipitators. Fabric filters are useful in controlling particulate matter less than or equal to 10 micrometers (μm) in diameter (PM₁₀) and particulate matter less than or equal to 2.5 μm in diameter (PM_{2.5}). Fabric filters may be good candidates for collecting fly ash from low-sulfur coals or containing high unburned carbon levels and are relatively difficult to collect with electrostatic precipitators. (EPA, 2000)

AT-A-GLANCE TABLE FOR POINT SOURCES

References:

EPA, 1998a: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, Chapter 5, EPA 453/B-96-001, Research Triangle Park, NC. December 1998.

EPA, 1998b: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

EPA, 2000: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Fabric Filter - Pulse-Jet Cleaned Type," April 2000.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.ary 1995.

STAPPA/ALAPCO, 1996: State and Territorial Air Pollution Program Administrators - Association of Local Air Pollution Control Officials, Controlling Particulate Matter Under the Clean Air Act: A Menu of Options, Washington, DC, July 1996

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Industrial Boilers - Wood

Control Measure Name: Dry ESP-Wire Plate Type

Rule Name: Not Applicable

Pechan Measure Code: P2022

POD: 202

Application: This control is the use of dry electrostatic precipitators (ESP) to reduce PM emissions. An ESP uses electrical forces to move particles in an exhaust stream onto collector plates. Electrodes in the center of the flow are maintained at high voltage and generate an electrical field forcing particles to the collector walls. In dry ESPs, the collectors are knocked by various mechanical means to dislodge the particulate, which slides downward into a hopper.

This control applies to operations with wood-fired industrial boilers, including those classified under the following SCCs 10200901, 10200902, 10200903, 10200904, 10200905, 10200906, 10200907.

Affected SCC:

10200901 Industrial, Wood/Bark Waste, Bark-fired Boiler (> 50,000 Lb Steam)
10200902 Industrial, Wood/Bark Waste, Wood/Bark-fired Boiler (> 50,000 Lb Steam)
10200903 Industrial, Wood/Bark Waste, Wood-fired Boiler (> 50,000 Lb Steam)
10200904 Wood/Bark Waste, Bark-fired Boiler (< 50,000 Lb Steam)
10200905 Wood/Bark Waste, Wood/Bark-fired Boiler (< 50,000 Lb Steam)
10200906 Industrial, Wood/Bark Waste, Wood-fired Boiler (< 50,000 Lb Steam)
10200907 Wood/Bark Waste, Wood Cogeneration

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: PM10 control efficiency is 98% from uncontrolled; PM2.5 control efficiency is 95% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs for ESPs of conventional design under typical operating conditions are developed using EPA cost estimating spreadsheets (EPA, 1996). When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan, 2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 1999). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

AT-A-GLANCE TABLE FOR POINT SOURCES

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$15 to \$50 per scfm
Typical value is \$27 per scfm

O&M Costs:

Range from \$4 to \$40 per scfm
Typical value is \$16 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for ESP (EPA, 1996). O&M costs were calculated for three model plants with flow rates of 200 and 500 thousand acfm and 1 million acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust loading of 6.0 grains per cubic feet. The operating time was assumed to be 8640 hours per year. The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.067	\$/kW-hr
Dust disposal	25	\$/ton disposed

Note: All costs are in 1995 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$40 to \$250 per ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$110 per ton PM10 reduced. (1995\$)

Comments:

Status: Demonstrated	Last Reviewed: 2001
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Additional Information:

The burning of wood and bark waste in boilers is mostly confined to industries where wood and bark waste is available as a byproduct. Wood and bark waste is burned to obtain heat energy and to alleviate possible solid waste disposal problems. In boilers, the waste is burned in the form of hogged wood, sawdust, shavings, chips, sander dust, or wood trim. Bark is the major type of waste burned in "power" boilers at pulp and paper mills. At lumber, furniture, and plywood plants, either a mixture of wood and bark waste or wood waste alone is burned most frequently (EPA, 1995).

ESPs are used when control efficiencies of 95 percent or more are required. In the wire-plate ESP, the gas flows around vertical, metal plates. The electrodes are long, weighted wires hanging

AT-A-GLANCE TABLE FOR POINT SOURCES

between the plates. The voltage applied to the electrodes causes the gas between the electrodes to break down, known as a "corona." The electrodes are most often given a negative polarity because a negative corona supports a higher voltage than a positive corona.

Certain types of losses affect control efficiency. The dislodging of the accumulated layer also projects some of the particles back into the gas stream. These particles are processed in later sections of the ESP, but the particles from the last section have no chance to be recaptured. Due to the space needed at the top of the ESP for nonelectrified components, part of the stream may flow around the charged zones. This is called "sneakage" and places an upper limit on the collection efficiency of the ESP. Anti-sneakage baffles are used to force the sneakage flow to mix with the main gas stream for collection in later sections (EPA, 1998).

Another factor in the performance of ESPs is the resistivity of the collected material. All the ion current must pass through the collected layer to reach the ground plates. This creates an electric field in the layer, and it can become large enough to cause electrical breakdown. When this occurs, new ions of the wrong polarity are injected into the wire-plate gap reducing the charge on the particles, which may cause sparking. This condition is called "back corona." When this happens the collection ability of the unit is reduced. At low resistivities the particles are held on the plates so loosely that reentrainment levels are much higher. Hence, care must be taken in measuring or estimating resistivity because it is strongly affected by such variables as temperature, moisture, gas composition, particle composition, and surface characteristics (EPA, 1999).

Dusts with high resistivities are also not well-suited for collection in dry ESPs. These particles are not easily charged nor easily collected. High-resistivity particles form ash layers with very high voltage gradients on the collecting electrodes lead to back corona, reducing the charge on particles and lowering collection efficiency. Fly ash from the combustion of low-sulfur coal typically has a high resistivity, and thus is difficult to collect using dry ESPs (EPA, 1999).

References:

EPA, 1995: U.S. Environmental Protection Agency, "Compilation of Air Pollutant Emission Factors," AP-42, Volume I, Fifth Edition, Research Triangle Park, NC, January 1995.

EPA, 1996: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, EPA 453/B-96-001, Research Triangle Park, NC. February 1996.

EPA, 1998: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

EPA, 1999: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Dry Electrostatic Precipitator (ESP) - Wire-Plate Type," May 1999.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Industrial Boilers - Wood

Control Measure Name: Fabric Filter (Reverse-Air Cleaned Type)

Rule Name: Not Applicable

Pechan Measure Code: P2023

POD: 202

Application: This control is the use of a reverse-air cleaned fabric filter to reduce PM emissions from waste streams. In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Reverse-air cleaning is performed by forcing clean air through the filters in the opposite direction of the dusty gas flow. The change in direction of the gas flow causes the bag to flex and crack the filter cake allowing for internal cake collection.

This control applies to operations with wood-fired boilers, classified under the following SCCs: 10200901, 10200902, 10200903, 10200904, 10200905, 10200906, 10200907.

Affected SCC:

10200901 Industrial, Wood/Bark Waste, Bark-fired Boiler (> 50,000 Lb Steam)
10200902 Industrial, Wood/Bark Waste, Wood/Bark-fired Boiler (> 50,000 Lb Steam)
10200903 Industrial, Wood/Bark Waste, Wood-fired Boiler (> 50,000 Lb Steam)
10200904 Wood/Bark Waste, Bark-fired Boiler (< 50,000 Lb Steam)
10200905 Wood/Bark Waste, Wood/Bark-fired Boiler (< 50,000 Lb Steam)
10200906 Industrial, Wood/Bark Waste, Wood-fired Boiler (< 50,000 Lb Steam)
10200907 Wood/Bark Waste, Wood Cogeneration

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 99% from uncontrolled for both PM10 and PM2.5

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs for reverse-air cleaned systems are generated using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan,2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 2000). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets

AT-A-GLANCE TABLE FOR POINT SOURCES

were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$9 to \$84 per scfm
Typical value is \$34 per scfm

O&M Costs:

Range from \$6 to \$27 per scfm
Typical value is \$13 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). O&M costs were calculated for three model plants with flow rates of 25, 75 and 150 thousand acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust loading of 4.0 grains per cubic feet. The operating time was assumed to be 8760 hours per year. An average bag cost was estimated using the costs for standard bag types. Capital recovery for the periodic replacement of bags was included in the O&M cost of the bags using a bag life of 2 years (EPA, 1998a). The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.0671	\$/kW-hr
Compressed air	0.25	\$/1000 scf
Dust disposal	25	\$/ton disposed

Note: All costs are in 1998 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$53 to \$337 per ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$148 per ton PM10 reduced. (1998\$)

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

The burning of wood and bark waste in boilers is mostly confined to industries where wood and bark waste is available as a byproduct. Wood and bark waste is burned to the burning of wood and bark waste in boilers is mostly confined to industries where wood and bark waste is available as a byproduct. Wood and bark waste is burned to obtain heat energy and to alleviate possible solid waste disposal problems. In boilers, the waste is burned in the form of hogged wood, sawdust, shavings, chips, sander dust, or wood trim. Bark is the major type of waste burned in "power" boilers at pulp and paper mills. At lumber, furniture, and plywood plants, either a mixture of wood and bark waste or wood waste alone is burned most frequently (EPA, 1995).

AT-A-GLANCE TABLE FOR POINT SOURCES

The cost estimates assume a conventional design under typical operating conditions. The costs do not include any auxiliary equipment (EPA, 2000).

The capital cost for the reverse-jet cleaned fabric baghouse is based on information provided by a manufacturer (EPA, 2000). The capital cost includes only the purchased equipment cost.

Costs are primarily based on volumetric flow rate and the amount of PM in the waste stream. In general, a small unit controlling a low pollutant levels will not be as cost effective as a large unit controlling a high pollutant levels. (EPA, 2000)

Pollutants requiring a high level of control or the fabric filters to be constructed of special materials will increase the costs of the system (EPA, 1998a). The additional costs for controlling complex streams are not reflected in the estimates. For these systems, the capital cost could increase by as much as 40% and the O&M cost could increase by as much as 5%. (EPA, 2000)

In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Fabric filters may be in the form of sheets, cartridges, or bags, with many individual filter units together in a group. Bags are the most common type of filter. The dust cake that forms on the filter from the collected PM can significantly increase collection efficiency. (EPA, 2000)

Reverse-air cleaning is a popular filter cleaning method as it has been used extensively and improved over the years. It is a gentler but sometimes less effective clearing mechanism than mechanical shaking. Reverse-air cleaning is performed by forcing clean air through the filters in the opposite direction of the dusty gas flow. The change in direction of the gas flow causes the bag to flex and crack the filter cake allowing for internal cake collection (EPA, 2000).

The most common design is to have separate compartments within the fabric filter so that each can be isolated and cleaned separately while the others continue to treat the dusty gas. There are several methods of reversing the flow through the filters. One method of providing the reverse flow is by the use of a fan or cleaned gas from other compartments. Reverse-air cleaning only used alone in cases where the dust releases easily from the fabric. In many instances, reverse-air is used along with shaking, pulsing or sonic horns (EPA, 1998b).

Fabric filters are useful for collecting particles with resistivities either too low or too high for collection with electrostatic precipitators. Fabric filters are useful in controlling particulate matter less than or equal to 10 micrometers (μm) in diameter (PM₁₀) and particulate matter less than or equal to 2.5 μm in diameter (PM_{2.5}). Fabric filters may be good candidates for collecting fly ash from low-sulfur coals or containing high unburned carbon levels and are relatively difficult to collect with electrostatic precipitators. (EPA, 2000)

References:

EPA, 1995: U.S. Environmental Protection Agency, "Compilation of Air Pollutant Emission Factors," AP-42, Volume I, Fifth Edition, Research Triangle Park, NC, January 1995. EPA, 1998b: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter, EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

EPA, 1998a: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, Chapter 5, EPA 453/B-96-001, Research Triangle Park, NC. December 1998.

AT-A-GLANCE TABLE FOR POINT SOURCES

EPA, 2000: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Fabric Filter - Reverse-Air Cleaned Type," April 2000.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001. of Local Air Pollution Control Officials, Controlling Particulate Matter Under the Clean Air Act: A Menu of Options, Washington, DC, July 1996

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Industrial Boilers - Wood

Control Measure Name: Venturi Scrubber

Rule Name: Not Applicable

Pechan Measure Code: P2024

POD: 202

Application: The control is the use of a venturi scrubber to reduce PM emissions. A scrubber is a type of technology that removes air pollutants by inertial and diffusional interception. A venturi scrubber accelerates the waste gas stream to atomize the scrubbing liquid and to improve gas-liquid contact.

This control applies to operations with wood-fired boilers, including those classified under the following SCCs: 10200901, 10200902, 10200903, 1020904, 1020905, 1020906, and 1020907.

Affected SCC:

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: PM10 control efficiency is 93% from uncontrolled; PM2.5 control efficiency is 92% from uncontrolled

Equipment Life: 10 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The following are cost ranges for venturi wet scrubbers, developed using EPA cost-estimating spreadsheets (EPA, 1996) and referenced to the volumetric flow rate of the waste stream treated. When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan, 2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 1999). Total installed capital costs were annualized using a capital recovery factor, which is based on a 7 percent discount rate and the expected life of the control equipment (10 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of

AT-A-GLANCE TABLE FOR POINT SOURCES

equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$3 to \$28 per scfm
Typical value is \$11 per scfm

O&M Costs:

Range from \$4 to \$119 per scfm
Typical value is \$42 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for Impingement Plate Scrubbers (EPA, 1996). O&M costs were calculated for two model plants with flow rates of 2,000 and 150,000 acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. The model plants were assumed to have a dust loading of 3.0 grains per cubic feet. The operating time was assumed to be 8760 hours per year. An inlet water flow rate for the scrubber was assumed to be 9.4 lbs/min. The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.067	\$/kW-hr
Process water price	0.20	\$/1000 gal
Dust disposal	25	\$/ton disposed
Wastewater treatment	3.8	\$/ thousand gal treated

Note: All costs are in 1995 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$76 to \$2,100 per ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$751 per ton PM10 reduced. (1995\$)

Comments:

Status: Demonstrated	Last Reviewed: 2001
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Additional Information:

The burning of wood and bark waste in boilers is mostly confined to industries where wood and bark waste is available as a byproduct. Wood and bark waste is burned to obtain heat energy and to alleviate possible solid waste disposal problems. In boilers, the waste is burned in the form of hogged wood, sawdust, shavings, chips, sander dust, or wood trim. Bark is the major type of waste burned in "power" boilers at pulp and paper mills. At lumber, furniture, and plywood plants, either a mixture of wood and bark waste or wood waste alone is burned most frequently (EPA, 1995).

The costs do not include costs for post-treatment or disposal of used solvent or waste. Actual costs can be substantially higher than in the ranges shown for applications which require expensive materials, solvents, or treatment methods (EPA, 1999). As a rule, smaller units controlling a low concentration waste stream will be much more expensive (per unit volumetric flow rate) than a large unit cleaning a high pollutant load flow.

AT-A-GLANCE TABLE FOR POINT SOURCES

By product coke production is used to manufacture metallurgical coke by heating high-grade bituminous coal (low sulfur and low ash) in an enclosed oven chamber without oxygen. The resulting solid material consists of elemental carbon and any minerals (ash) that were present in the coal blend that did not volatilize during the process. Sources of air emissions consist of coke oven doors, coke oven lids and off-takes, coke oven charging, coke oven pushing, coke oven underfire stack, coke quenching, battery venting, and coke by-product-recovery plants.

A venturi scrubber accelerates the waste gas stream to improve gas-liquid contact. In a venturi scrubber, a "throat" section is built into the duct that forces the gas stream to accelerate (EPA, 1999). As the gas enters the venturi throat, both gas velocity and turbulence increase.

After the throat section, the mixture decelerates, and further impacts occur causing the droplets to agglomerate. Once the particles have been captured by the liquid, the wetted PM and excess liquid are separated from the gas stream through entrainment. This section usually consists of a cyclonic separator and/or a mist eliminator (EPA, 1998; Corbitt, 1990).

For PM applications, wet scrubbers generate waste, either a slurry or wet sludge. This creates the need for both wastewater treatment and solid waste disposal. Initially, the slurry is treated to separate the solid waste from the water (EPA, 1999). The treated water can then be reused or discharged. Once the water is removed, the remaining waste will be in the form of a solid or sludge. If the solid waste is inert and nontoxic, it can generally be land filled. Hazardous wastes will have more stringent procedures for disposal. In some cases, the solid waste may have value and can be sold or recycled (EPA, 1998).

References:

Corbitt, 1990: "Standard Handbook of Environmental Engineering," edited by Robert A. Corbitt, McGraw-Hill, New York, NY, 1990.

EPA, 1995: U.S. Environmental Protection Agency, "Compilation of Air Pollutant Emission Factors," AP-42, Volume I, Fifth Edition, Research Triangle Park, NC, January 1995.

EPA, 1996: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, EPA 453/B-96-001, Research Triangle Park, NC February.

EPA, 1998: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

EPA, 1999: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Venturi Scrubber," July 1999.

Heumann, 1997: W. L. Heumann, "Industrial Air Pollution Control Systems," McGraw Hill Publishers, Inc., Washington, D.C., 1997.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

STAPPA/ALAPCO, 1996: State and Territorial Air Pollution Program Administrators and Association of Local Air Pollution Control Officials, "Controlling Particulate Matter Under the Clean Air Act: A Menu of Options," July 1996.

AT-A-GLANCE TABLE FOR POINT SOURCES

STAPPA/ALAPCO, 1996: State and Territorial Air Pollution Program Administrators - Association of Local Air Pollution Control Officials, "Controlling Particulate Matter Under the Clean Air Act: A Menu of Options," Washington, DC, July 1996

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Industrial Boilers - Wood

Control Measure Name: Increased Monitoring Frequency (IMF) of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P3202

POD: 202

Application: This measure is to conduct improved monitoring for PM_{2.5} emissions at stationary sources. Improved monitoring in this case means increasing the monitoring frequency of electrostatic precipitators, scrubbers, and fabric filters from once per day to four times per hour, with no change in monitoring technique.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (Barr and Schaffner) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

102009** Industrial, Wood/Bark Waste

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 6.5% for both PM₁₀ and PM_{2.5}

Equipment Life: Not applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs included the incremental record keeping and reporting associated with the increased monitoring frequency. Labor rates for 2003 were made that were obtained from the Bureau of Labor Statistics (labor rates include 140 percent overhead). The incremental costs included a one-time cost for development of the improved monitoring and recurring annual burden costs for incremental record keeping, reporting, and certification activities.

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$620 per ton PM reduced (2003\$).

Comments:

Status:

Last Reviewed: 2004

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM2.5 Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 2003.

BLS, 2003: Bureau of Labor Statistics, "Employer Costs for Employee Compensation – June 2003," Table 12, page 16, 2003.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Industrial Boilers - Wood

Control Measure Name: CEM Upgrade and Increased Monitoring Frequency of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P4202

POD: 202

Application: This measure examines the impacts of improving the PM monitoring technique at units currently using an ESP, scrubber, or fabric filter. In this improved technique scenario, the monitoring technique is upgraded to a PM continuous emission monitor. This improved monitoring technique also results in an increase to the monitoring frequency because a PM CEMS can make a measurement every 7.5 minutes. The monitoring frequency increases from once per day to eight times per hour.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (see References) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

102009** Industrial, Wood/Bark Waste

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 7.7% for both PM10 and PM2.5

Equipment Life: Unknown

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The total capital and annual operating costs for implementing an improved monitoring technique are calculated based on data from the EPA CEMS Cost Model and the PM CEMS Knowledge document. Labor rates in the EPA CEMS Cost Model are scaled to reflect 2003 labor rates (including 140 percent overhead) provided by the Bureau of Labor Statistics.

The cost effectiveness at a percent excess emission rate of 0.46 percent is \$5,200 per ton of PM2.5. This is based on a \$34 million capital investment cost, and a \$14 million total annualized cost when applied to 128 facilities.

Note: All costs are in 2003 dollars.

AT-A-GLANCE TABLE FOR POINT SOURCES

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$5,200 per ton PM reduced (2003\$).

Comments:

Status:

Last Reviewed: 2004

Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM_{2.5} Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 8, 2003.

EPA CEMS Cost Model, Version 3.0, U.S. Environmental Protection Agency.

EPA, 2000: U.S. Environmental Protection Agency, "Current Knowledge of Particulate Matter (PM) Continuous Emissions Monitoring," Chapter 9, PM CEMS Cost, September 8, 2000.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Mineral Products - Cement Manufacture

Control Measure Name: Fabric Filter (Pulse Jet Type)

Rule Name: Not Applicable

Pechan Measure Code: P2181

POD: 218

Application: This control is the addition of a pulse-jet cleaned fabric filter to reduce PM emissions from waste streams. In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Particulate-laden gas flows into the filter bag from the outside to the inside. The particles collected on the outside drop into a hopper below the fabric filter. During pulse-jet cleaning, a short burst of high pressure air is injected into the bags, dislodging the dust cake.

This control applies to electricity generation sources powered by pulverized dry-bottom and bituminous/subbituminous coal.

Affected SCC:

30500606 Mineral Products, Cement Manufacturing (Dry Process), Kilns
30500607 Cement Manufacturing (Dry Process), Raw Material Unloading
30500608 Cement Manufacturing (Dry Process), Raw Material Piles
30500609 Mineral Products, Cement Manufacturing (Dry Process), Primary Crushing
30500610 Mineral Products, Cement Manufacturing (Dry Process), Secondary Crushing
30500611 Mineral Products, Cement Manufacturing (Dry Process), Screening
30500612 Mineral Products, Cement Manufacturing (Dry Process), Raw Mat'l Transfer
30500613 Mineral Products, Cement Manufacturing (Dry Process), Raw Mat'l Grinding & Drying
30500614 Mineral Products, Cement Manufacturing (Dry Process), Clinker Cooler
30500615 Cement Manufacturing (Dry Process), Clinker Piles
30500616 Mineral Products, Cement Manufacturing (Dry Process), Clinker Transfer
30500617 Mineral Products, Cement Manufacturing (Dry Process), Clinker Grinding
30500618 Mineral Products, Cement Manufacturing (Dry Process), Cement Silos
30500619 Mineral Products, Cement Manufacturing (Dry Process), Cement Load Out
30500621 Cement Manufacturing (Dry Process), Pulverized Coal Kiln Feed Units
30500622 Cement Manufacturing (Dry Process), Preheater Kiln
30500623 Cement Manufacturing (Dry Process), Preheater/Precalciner Kiln
30500624 Cement Manufacturing (Dry Process), Raw Mill Feed Belt
30500626 Cement Manufacturing (Dry Process), Raw Mill Air Separator
30500699 Cement Manufacturing (Dry Process), Other Not Classified
30500706 Mineral Products, Cement Manufacturing (Wet Process), Kilns
30500707 Cement Manufacturing (Wet Process), Raw Material Unloading
30500708 Cement Manufacturing (Wet Process), Raw Material Piles
30500709 Cement Manufacturing (Wet Process), Primary Crushing
30500710 Cement Manufacturing (Wet Process), Secondary Crushing
30500712 Cement Manufacturing (Wet Process), Raw Material Transfer
30500714 Mineral Products, Cement Manufacturing (Wet Process), Clinker Cooler
30500716 Cement Manufacturing (Wet Process), Clinker Transfer
30500717 Cement Manufacturing (Wet Process), Clinker Grinding
30500718 Mineral Products, Cement Manufacturing (Wet Process), Cement Silos
30500719 Mineral Products, Cement Manufacturing (Wet Process), Cement Load Out
30500799 Mineral Products, Cement Manufacturing (Wet Process), Other Not Classified

AT-A-GLANCE TABLE FOR POINT SOURCES

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 99% from uncontrolled for both PM10 and PM2.5

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs for pulse-jet cleaned systems are generated using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan, 2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 2000). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$6 to \$26 per scfm
Typical value is \$13 per scfm

O&M Costs:

Range from \$5 to \$24 per scfm
Typical value is \$11 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). O&M costs were calculated for three model plants with flow rates of 25, 75 and 150 thousand acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust loading of 4.0 grains per cubic feet. The operating time was assumed to be 8760 hours per year. An average bag cost was estimated using the costs for standard bag

AT-A-GLANCE TABLE FOR POINT SOURCES

types. Capital recovery for the periodic replacement of bags was included in the O&M cost of the bags using a bag life of 2 years (EPA, 1998a). The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.0671	\$/kW-hr
Compressed air	0.25	\$/1000 scf
Dust disposal	25	\$/ton disposed

Note: All costs are in 1998 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$42 to \$266 per ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$117 per ton PM10 reduced. (1998\$)

Comments:

Status: Demonstrated	Last Reviewed: 2001
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Additional Information:

The largest source of particulate emissions at a cement plant is the kiln used to produce clinker. Cement kilns are rotary kilns, which are slowly rotating refractory-lined steel cylinders inclined slightly from the horizontal. Raw materials are fed into the top end of the kiln and spend several hours traversing the kiln. In wet process kilns (SCC 30500706), the raw materials are fed as a wet slurry. During this time, the raw materials are heated by a flame at the discharge end of the kiln. This heating dries the raw materials, converts limestone to lime, and promotes reaction between and fusion of the separate ingredients to form clinker. Clinker exiting the kiln is fed to a clinker cooler (SCC 30500714) for cooling before storage and further processing (STAPPA/ALAPCO, 1996).

The cost estimates assume a conventional design under typical operating conditions and do not include auxiliary equipment such as fans and ductwork. The costs for pulse-jet cleaned systems are generated using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a).

Costs are primarily based on volumetric flow rate and the amount of PM in the waste stream. In general, a small unit controlling a low pollutant levels will not be as cost effective as a large unit controlling a high pollutant levels. (EPA, 2000)

Pollutants requiring a high level of control or the fabric filters to be constructed of special materials will increase the costs of the system (EPA, 1998a). The additional costs for controlling complex waste streams are not included in the estimates. For these systems, the capital cost could increase by as much as 75% and the operational and maintenance (O&M) cost could increase by as much as 20% (EPA, 2000).

In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Fabric filters may be in the form of sheets, cartridges, or bags, with many individual filter units together in a group. Bags are the most common type of filter. The dust cake that forms on the filter from the collected PM can significantly increase collection efficiency. (EPA, 2000)

Pulse-jet cleaning of fabric filters is a relatively new type of fabric filter, as they have only been used for the past 30 years. This cleaning mechanism has grown in popularity because it can treat high dust loadings, operate at constant pressure drop, and occupy less space than other types of fabric filters (EPA, 2000). Particulate-laden gas flows into the bag. The gas flows from the outside to the

AT-A-GLANCE TABLE FOR POINT SOURCES

inside of the bags, and then out the gas exhaust. The particles collected on the outside drop into a hopper below the fabric filter (EPA, 1998b).

During pulse-jet cleaning, a short burst of high pressure air is injected into the bags (EPA, 1998b). The pulse is blown through a venturi nozzle at the top of the bags and establishes a shock wave that continues onto the bottom of the bag. The wave flexes the fabric dislodging the dust cake.

There are several unique attributes of pulse-jet cleaning. The cleaning pulse is very brief allowing the flow of dusty gas to continue during cleaning. The bags not being cleaned continue to filter, taking on extra duty from the bags being cleaned (EPA, 2000). Pulse-jet cleaning is more intense and occurs with greater frequency than the other fabric filter cleaning methods. The cleaning dislodges nearly all of the dust cake each time the bag is pulsed. Pulse-jet filters, as a result, do not rely on a dust cake to provide filtration. Felted (non-woven) fabrics are used in these types of filters because they do not require a dust cake. Also it has been found that woven fabrics used with pulse-jet cleaning leak dust after they are cleaned (EPA, 1998b).

Since bags cleaned by the pulse-jet method do not need to be isolated for cleaning, pulsejet cleaned fabric filters do not need extra compartments to maintain adequate filtration during cleaning. Also, because of the intense and frequent nature of the cleaning, they can treat higher gas flow rates with higher dust loadings. Consequently, fabric filters cleaned by the pulse-jet method can be smaller than other filters in the treatment of the same amount of gas and dust, making higher gas-to-cloth ratios achievable (EPA, 1998b).

Fabric filters are useful for collecting particles with resistivities either too low or too high for collection with electrostatic precipitators. Fabric filters are useful in controlling particulate matter less than or equal to 10 micrometers (μm) in diameter (PM₁₀) and particulate matter less than or equal to 2.5 μm in diameter (PM_{2.5}). Fabric filters may be good candidates for collecting fly ash from low-sulfur coals or containing high unburned carbon levels and are relatively difficult to collect with electrostatic precipitators. (EPA, 2000)

References:

EPA, 1998a: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, Chapter 5, EPA 453/B-96-001, Research Triangle Park, NC. December 1998.

EPA, 1998b: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

EPA, 2000: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Fabric Filter - Pulse-Jet Cleaned Type," April 2000.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

STAPPA/ALAPCO, 1996: State and Territorial Air Pollution Program Administrators - Association of Local Air Pollution Control Officials, Controlling Particulate Matter Under the Clean Air Act: A Menu of Options, Washington, DC, July 1996.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Mineral Products - Cement Manufacture

Control Measure Name: Fabric Filter (Mech. Shaker Type)

Rule Name: Not Applicable

Pechan Measure Code: P2182

POD: 218

Application: This control is the addition of a mechanical shaker type fabric filter to reduce PM emissions. In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. The gas stream is drawn from beneath a cell plate in the floor and into the filter bags. The gas proceeds from the inside to the outside of the filter bags. The particles collect on the inside of the bags, forming a filter cake. In mechanical shaking units, the tops of bags are attached to a shaker bar, moved briskly to clean the bags.

This control applies to cement manufacturing operations.

Affected SCC:

30500606 Mineral Products, Cement Manufacturing (Dry Process), Kilns
30500607 Cement Manufacturing (Dry Process), Raw Material Unloading
30500608 Cement Manufacturing (Dry Process), Raw Material Piles
30500609 Mineral Products, Cement Manufacturing (Dry Process), Primary Crushing
30500610 Mineral Products, Cement Manufacturing (Dry Process), Secondary Crushing
30500611 Mineral Products, Cement Manufacturing (Dry Process), Screening
30500612 Mineral Products, Cement Manufacturing (Dry Process), Raw Mat'l Transfer
30500613 Mineral Products, Cement Manufacturing (Dry Process), Raw Mat'l Grinding & Drying
30500614 Mineral Products, Cement Manufacturing (Dry Process), Clinker Cooler
30500615 Cement Manufacturing (Dry Process), Clinker Piles
30500616 Mineral Products, Cement Manufacturing (Dry Process), Clinker Transfer
30500617 Mineral Products, Cement Manufacturing (Dry Process), Clinker Grinding
30500618 Mineral Products, Cement Manufacturing (Dry Process), Cement Silos
30500619 Mineral Products, Cement Manufacturing (Dry Process), Cement Load Out
30500621 Cement Manufacturing (Dry Process), Pulverized Coal Kiln Feed Units
30500622 Cement Manufacturing (Dry Process), Preheater Kiln
30500623 Cement Manufacturing (Dry Process), Preheater/Precalciner Kiln
30500624 Cement Manufacturing (Dry Process), Raw Mill Feed Belt
30500626 Cement Manufacturing (Dry Process), Raw Mill Air Separator
30500699 Cement Manufacturing (Dry Process), Other Not Classified
30500706 Mineral Products, Cement Manufacturing (Wet Process), Kilns
30500707 Cement Manufacturing (Wet Process), Raw Material Unloading
30500708 Cement Manufacturing (Wet Process), Raw Material Piles
30500709 Cement Manufacturing (Wet Process), Primary Crushing
30500710 Cement Manufacturing (Wet Process), Secondary Crushing
30500712 Cement Manufacturing (Wet Process), Raw Material Transfer
30500714 Mineral Products, Cement Manufacturing (Wet Process), Clinker Cooler
30500716 Cement Manufacturing (Wet Process), Clinker Transfer
30500717 Cement Manufacturing (Wet Process), Clinker Grinding
30500718 Mineral Products, Cement Manufacturing (Wet Process), Cement Silos
30500719 Mineral Products, Cement Manufacturing (Wet Process), Cement Load Out
30500799 Mineral Products, Cement Manufacturing (Wet Process), Other Not Classified

AT-A-GLANCE TABLE FOR POINT SOURCES

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 99% from uncontrolled for both PM10 and PM2.5

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs for mechanical shaker cleaned systems are generated using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan, 2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 2000). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$8 to \$71 per scfm
Typical value is \$29 per scfm

O&M Costs:

Range from \$4 to \$24 per scfm
Typical value is \$11 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). O&M costs were calculated for three model plants with flow rates of 25, 75 and 150 thousand acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust loading of 4.0 grains per cubic feet. The operating time was assumed to be 8760 hours per year. An average bag cost was estimated using the costs for standard bag

AT-A-GLANCE TABLE FOR POINT SOURCES

types. Capital recovery for the periodic replacement of bags was included in the O&M cost of the bags using a bag life of 2 years (EPA, 1998a). The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.0671	\$/kW-hr
Compressed air	0.25	\$/1000 scf
Dust disposal	25	\$/ton disposed

Note: All costs are in 1998 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$37 to \$303 per ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$126 per ton PM10 reduced. (1998\$)

Comments:

Status: Demonstrated	Last Reviewed: 2001
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Additional Information:

The largest source of particulate emissions at a cement plant is the kiln used to produce clinker. Cement kilns are rotary kilns, which are slowly rotating refractory-lined steel cylinders inclined slightly from the horizontal. Raw materials are fed into the top end of the kiln and spend several hours traversing the kiln. In wet process kilns (SCC 30500706), the raw materials are fed as a wet slurry. During this time, the raw materials are heated by a flame at the discharge end of the kiln. This heating dries the raw materials, converts limestone to lime, and promotes reaction between and fusion of the separate ingredients to form clinker. Clinker exiting the kiln is fed to a clinker cooler (SCC 30500714) for cooling before storage and further processing (STAPPA/ALAPCO, 1996).

Cost estimates assume a conventional design under typical operating conditions. The costs do not include auxiliary equipment such as fans and ductwork. (EPA, 2000)

Costs are primarily based on volumetric flow rate and the amount of PM in the waste stream. In general, a small unit controlling a low pollutant levels will not be as cost effective as a large unit controlling a high pollutant levels. (EPA, 2000)

Pollutants requiring a high level of control or the fabric filters to be constructed of special materials will increase the costs of the system (EPA, 1998a). The additional costs for controlling complex waste streams are not included in the estimates. For these systems, the capital cost could increase by as much as 30% and the O&M cost could increase by as much as 7%.

In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Fabric filters may be in the form of sheets, cartridges, or bags, with many individual filter units together in a group. Bags are the most common type of filter. The dust cake that forms on the filter from the collected PM can significantly increase collection efficiency. (EPA, 2000)

Mechanical shaking is a popular cleaning method because it is both simple and effective. In typical operation, dusty gas enters an inlet pipe to the fabric filter and very large particles are removed using a baffle plate fall into the hopper. The gas stream is drawn from beneath a cell plate in the floor and into the filter bags (EPA, 2000). The gas proceeds from the inside to the outside of the filter bags. The particles collect on the inside of the bags, forming a filter cake. In mechanical shaking units, the tops of bags are attached to a shaker bar, moved briskly (usually in a horizontal

AT-A-GLANCE TABLE FOR POINT SOURCES

direction) to clean the bags. The shaker bars are operated by mechanical motors or by hand (EPA, 1998b)..

Fabric filters are useful for collecting particles with resistivities either too low or too high for collection with electrostatic precipitators. Fabric filters are useful in controlling particulate matter less than or equal to 10 micrometers (μm) in diameter (PM10) and particulate matter less than or equal to 2.5 μm in diameter (PM2.5). Fabric filters may be good candidates for collecting fly ash from low-sulfur coals or containing high unburned carbon levels and are relatively difficult to collect with electrostatic precipitators. (EPA, 2000)

References:

EPA, 1998a: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, Chapter 5, EPA 453/B-96-001, Research Triangle Park, NC. December 1998.

EPA, 1998b: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

EPA, 2000: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Fabric Filter - Mechanical Shaker Cleaned Type," August 2000.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

STAPPA/ALAPCO, 1996: State and Territorial Air Pollution Program Administrators - Association of Local Air Pollution Control Officials, Controlling Particulate Matter Under the Clean Air Act: A Menu of Options, Washington, DC, July 1996.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Mineral Products - Cement Manufacture

Control Measure Name: Dry ESP-Wire Plate Type

Rule Name: Not Applicable

Pechan Measure Code: P2183

POD: 218

Application: This control is the use of dry electrostatic precipitators (ESP) to reduce PM emissions. An ESP uses electrical forces to move particles in an exhaust stream onto collector plates. Electrodes in the center of the flow are maintained at high voltage and generate an electrical field forcing particles to the collector walls. In dry ESPs, the collectors are knocked by various mechanical means to dislodge the particulate, which slides downward into a hopper.

This control applies to cement manufacturing operations.

Affected SCC:

30500606 Mineral Products, Cement Manufacturing (Dry Process), Kilns
30500607 Cement Manufacturing (Dry Process), Raw Material Unloading
30500608 Cement Manufacturing (Dry Process), Raw Material Piles
30500609 Mineral Products, Cement Manufacturing (Dry Process), Primary Crushing
30500610 Mineral Products, Cement Manufacturing (Dry Process), Secondary Crushing
30500611 Mineral Products, Cement Manufacturing (Dry Process), Screening
30500612 Mineral Products, Cement Manufacturing (Dry Process), Raw Mat'l Transfer
30500613 Mineral Products, Cement Manufacturing (Dry Process), Raw Mat'l Grinding & Drying
30500614 Mineral Products, Cement Manufacturing (Dry Process), Clinker Cooler
30500615 Cement Manufacturing (Dry Process), Clinker Piles
30500616 Mineral Products, Cement Manufacturing (Dry Process), Clinker Transfer
30500617 Mineral Products, Cement Manufacturing (Dry Process), Clinker Grinding
30500618 Mineral Products, Cement Manufacturing (Dry Process), Cement Silos
30500619 Mineral Products, Cement Manufacturing (Dry Process), Cement Load Out
30500621 Cement Manufacturing (Dry Process), Pulverized Coal Kiln Feed Units
30500622 Cement Manufacturing (Dry Process), Preheater Kiln
30500623 Cement Manufacturing (Dry Process), Preheater/Precalciner Kiln
30500624 Cement Manufacturing (Dry Process), Raw Mill Feed Belt
30500626 Cement Manufacturing (Dry Process), Raw Mill Air Separator
30500699 Cement Manufacturing (Dry Process), Other Not Classified
30500706 Mineral Products, Cement Manufacturing (Wet Process), Kilns
30500707 Cement Manufacturing (Wet Process), Raw Material Unloading
30500708 Cement Manufacturing (Wet Process), Raw Material Piles
30500709 Cement Manufacturing (Wet Process), Primary Crushing
30500710 Cement Manufacturing (Wet Process), Secondary Crushing
30500712 Cement Manufacturing (Wet Process), Raw Material Transfer
30500714 Mineral Products, Cement Manufacturing (Wet Process), Clinker Cooler
30500716 Cement Manufacturing (Wet Process), Clinker Transfer
30500717 Cement Manufacturing (Wet Process), Clinker Grinding
30500718 Mineral Products, Cement Manufacturing (Wet Process), Cement Silos
30500719 Mineral Products, Cement Manufacturing (Wet Process), Cement Load Out
30500799 Mineral Products, Cement Manufacturing (Wet Process), Other Not Classified

AT-A-GLANCE TABLE FOR POINT SOURCES

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: PM10 control efficiency is 98% from uncontrolled; PM2.5 control efficiency is 95% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs for ESPs of conventional design under typical operating conditions are developed using EPA cost estimating spreadsheets (EPA, 1996). When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan, 2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 1999). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$15 to \$50 per scfm
Typical value is \$27 per scfm

O&M Costs:

Range from \$4 to \$40 per scfm
Typical value is \$16 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for ESP (EPA, 1996). O&M costs were calculated for three model plants with flow rates of 200 and 500 thousand acfm and 1 million acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust loading of 6.0 grains per cubic feet. The operating time was assumed to be

AT-A-GLANCE TABLE FOR POINT SOURCES

8640 hours per year. The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.067	\$/kW-hr
Dust disposal	25	\$/ton disposed

Note: All costs are in 1995 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$40 to \$250 per ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$110 per ton PM10 reduced. (1995\$)

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

The largest source of particulate emissions at a cement plant is the kiln used to produce clinker. Cement kilns are rotary kilns, which are slowly rotating refractory-lined steel cylinders inclined slightly from the horizontal. Raw materials are fed into the top end of the kiln and spend several hours traversing the kiln. In wet process kilns (SCC 30500706), the raw materials are fed as a wet slurry. During this time, the raw materials are heated by a flame at the discharge end of the kiln. This heating dries the raw materials, converts limestone to lime, and promotes reaction between and fusion of the separate ingredients to form clinker. Clinker exiting the kiln is fed to a clinker cooler (SCC 30500714) for cooling before storage and further processing (STAPPA/ALAPCO, 1996).

In the wire-plate ESP, the gas flows around vertical, metal plates. The electrodes are long, weighted wires hanging between the plates. The voltage applied to the electrodes causes the gas between the electrodes to break down, known as a "corona." The electrodes are most often given a negative polarity because a negative corona supports a higher voltage than a positive corona.

Certain types of losses affect control efficiency. The dislodging of the accumulated layer also projects some of the particles back into the gas stream. These particles are processed in later sections of the ESP, but the particles from the last section have no chance to be recaptured. Due to the space needed at the top of the ESP for nonelectrified components, part of the stream may flow around the charged zones. This is called "sneakage" and places an upper limit on the collection efficiency of the ESP. Anti-sneakage baffles are used to force the sneakage flow to mix with the main gas stream for collection in later sections (EPA, 1998).

Another factor in the performance of ESPs is the resistivity of the collected material. All the ion current must pass through the collected layer to reach the ground plates. This creates an electric field in the layer, and it can become large enough to cause electrical breakdown. When this occurs, new ions of the wrong polarity are injected into the wire-plate gap reducing the charge on the particles, which may cause sparking. This condition is called "back corona." When this happens the collection ability of the unit is reduced. At low resistivities the particles are held on the plates so loosely that reentrainment levels are much higher. Hence, care must be taken in measuring or estimating resistivity because it is strongly affected by such variables as temperature, moisture, gas composition, particle composition, and surface characteristics (EPA, 1999).

Dusts with high resistivities are also not well-suited for collection in dry ESPs. These particles are not easily charged nor easily collected. High-resistivity particles form ash layers with very high voltage gradients on the collecting electrodes lead to back corona, reducing the charge on particles

AT-A-GLANCE TABLE FOR POINT SOURCES

and lowering collection efficiency. Fly ash from the combustion of low-sulfur coal typically has a high resistivity, and thus is difficult to collect using dry ESPs (EPA, 1999).

References:

EPA, 1996: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, EPA 453/B-96-001, Research Triangle Park, NC. February 1996.

EPA, 1998: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

EPA, 1999: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Dry Electrostatic Precipitator (ESP) - Wire-Plate Type," May 1999.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

STAPPA/ALAPCO, 1996: State and Territorial Air Pollution Program Administrators - Association of Local Air Pollution Control Officials, Controlling Particulate Matter Under the Clean Air Act: A Menu of Options, Washington, DC, July 1996.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Mineral Products - Cement Manufacture

Control Measure Name: Paper/Nonwoven Filters - Cartridge Collector Type

Rule Name: Not Applicable

Pechan Measure Code: P2184

POD: 218

Application: This control is the use of paper or non-woven filters (cartridge collector type) to reduce PM emissions. The waste gas stream is passed through the fibrous filter media causing PM in the gas stream to be collected on the media by sieving and other mechanisms.

This control measure applies to cement manufacturing operations.

Affected SCC:

30500606 Mineral Products, Cement Manufacturing (Dry Process), Kilns
 30500607 Cement Manufacturing (Dry Process), Raw Material Unloading
 30500608 Cement Manufacturing (Dry Process), Raw Material Piles
 30500609 Mineral Products, Cement Manufacturing (Dry Process), Primary Crushing
 30500610 Mineral Products, Cement Manufacturing (Dry Process), Secondary Crushing
 30500611 Mineral Products, Cement Manufacturing (Dry Process), Screening
 30500612 Mineral Products, Cement Manufacturing (Dry Process), Raw Mat'l Transfer
 30500613 Mineral Products, Cement Manufacturing (Dry Process), Raw Mat'l Grinding & Drying
 30500614 Mineral Products, Cement Manufacturing (Dry Process), Clinker Cooler
 30500615 Cement Manufacturing (Dry Process), Clinker Piles
 30500616 Mineral Products, Cement Manufacturing (Dry Process), Clinker Transfer
 30500617 Mineral Products, Cement Manufacturing (Dry Process), Clinker Grinding
 30500618 Mineral Products, Cement Manufacturing (Dry Process), Cement Silos
 30500619 Mineral Products, Cement Manufacturing (Dry Process), Cement Load Out
 30500621 Cement Manufacturing (Dry Process), Pulverized Coal Kiln Feed Units
 30500622 Cement Manufacturing (Dry Process), Preheater Kiln
 30500623 Cement Manufacturing (Dry Process), Preheater/Precalciner Kiln
 30500624 Cement Manufacturing (Dry Process), Raw Mill Feed Belt
 30500626 Cement Manufacturing (Dry Process), Raw Mill Air Separator
 30500699 Cement Manufacturing (Dry Process), Other Not Classified
 30500706 Mineral Products, Cement Manufacturing (Wet Process), Kilns
 30500707 Cement Manufacturing (Wet Process), Raw Material Unloading
 30500708 Cement Manufacturing (Wet Process), Raw Material Piles
 30500709 Cement Manufacturing (Wet Process), Primary Crushing
 30500710 Cement Manufacturing (Wet Process), Secondary Crushing
 30500712 Cement Manufacturing (Wet Process), Raw Material Transfer
 30500714 Mineral Products, Cement Manufacturing (Wet Process), Clinker Cooler
 30500716 Cement Manufacturing (Wet Process), Clinker Transfer
 30500717 Cement Manufacturing (Wet Process), Clinker Grinding
 30500718 Mineral Products, Cement Manufacturing (Wet Process), Cement Silos
 30500719 Mineral Products, Cement Manufacturing (Wet Process), Cement Load Out
 30500799 Mineral Products, Cement Manufacturing (Wet Process), Other Not Classified

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

AT-A-GLANCE TABLE FOR POINT SOURCES

Control Efficiency: 99% from uncontrolled for both PM10 and PM2.5

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs are generated using EPA's cost-estimating spreadsheets for fabric filters (EPA, 1998a). Costs are primarily driven by the waste stream volumetric flow rate and pollutant loading. When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan,2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 2000). Total installed capital costs were annualized using a capital recovery factor, which is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$7 to \$13 per scfm

Typical value is \$9 per scfm

O&M Costs:

Range from \$9 to \$25 per scfm

Typical value is \$14 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). O&M costs were calculated for three model plants with flow rates of 25, 75 and 150 thousand acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust loading of 4.0 grains per cubic feet. The operating time was assumed to be 8760 hours per year. An average cartridge cost was estimated using the costs for standard cartridge types. Capital recovery for the periodic replacement of cartridges was included in the O&M cost of the cartridges using a cartridge life of 2 years (EPA, 1998a). The following assumptions apply to the cost of utilities and disposal:

Electricity price 0.0671 \$/kW-hr

AT-A-GLANCE TABLE FOR POINT SOURCES

Compressed air	0.25	\$/1000 scf
Dust disposal	25	\$/ton disposed

Note: All costs are in 1998 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$85 to \$256 per ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$142 per ton PM10 reduced. (1998\$)

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

The largest source of particulate emissions at a cement plant is the kiln used to produce clinker. Cement kilns are rotary kilns, which are slowly rotating refractory-lined steel cylinders inclined slightly from the horizontal. Raw materials are fed into the top end of the kiln and spend several hours traversing the kiln. In wet process kilns (SCC 30500706), the raw materials are fed as a wet slurry. During this time, the raw materials are heated by a flame at the discharge end of the kiln. This heating dries the raw materials, converts limestone to lime, and promotes reaction between and fusion of the separate ingredients to form clinker. Clinker exiting the kiln is fed to a clinker cooler (SCC 30500714) for cooling before storage and further processing (STAPPA/ALAPCO, 1996).

The cost estimates assume a conventional design under typical operating conditions. Auxiliary equipment, such as fans and ductwork, is not included (EPA, 2000). Pollutants that require an unusually high level of control or that require the filter media or the unit itself to be constructed of special materials, such as Nomex® or stainless steel, will increase the costs of the system (EPA, 1998a). The additional costs for controlling more complex waste streams are not reflected in the estimates given below. For these types of systems, the capital cost could increase by as much as 75% and the O&M cost could increase by as much as 10%. In general, a small unit controlling a low pollutant loading will not be as cost effective as a large unit controlling a high pollutant loading (EPA, 2000).

Cartridge filters contain either a paper or nonwoven fibrous filter media (EPA, 2000). Paper media is generally made of materials such as cellulose and fiberglass. The dust cake that forms on the filter media from the collected PM can significantly increase collection efficiency (EPA, 1998b).

In general, the filter media is pleated to provide a larger surface area to volume flow rate. Close pleating, however, can cause PM to bridge the pleat bottom, effectively reducing the surface collection area (EPA, 1998b). Corrugated aluminum separators are used to prevent the pleats from collapsing (Heumann, 1997). There are variety of cartridge designs and dimensions. Typical designs include flat panels, V-shaped packs or cylindrical packs (Heumann, 1997). For certain applications, two cartridges may be placed in series.

Cartridge collectors are useful for collecting particles with resistivities either too low or too high for collection with electrostatic precipitators (STAPPA/ALAPCO, 1996). For similar air flow rates, cartridge collectors are compact in size compared to traditional bag

References:

EPA, 1998b: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, Chapter 5, EPA 453/B-96-001, Research Triangle Park, NC. December 1998.

AT-A-GLANCE TABLE FOR POINT SOURCES

EPA, 1998a: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

EPA, 2000: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Cartridge Collector with Pulse-Jet Cleaning," April 2000.

Heumann, 1997: W. L. Heumann, "Industrial Air Pollution Control Systems," McGraw Hill Publishers, Inc., Washington, D.C., 1997.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

STAPPA/ALAPCO, 1996: State and Territorial Air Pollution Program Administrators and Association of Local Air Pollution Control Officials, "Controlling Particulate Matter Under the Clean Air Act: A Menu of Options," July 1996.

STAPPA/ALAPCO, 1996: State and Territorial Air Pollution Program Administrators - Association of Local Air Pollution Control Officials, "Controlling Particulate Matter Under the Clean Air Act: A Menu of Options," Washington, DC, July 1996.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Mineral Products - Cement Manufacture

Control Measure Name: Fabric Filter (Reverse-Air Cleaned Type)

Rule Name: Not Applicable

Pechan Measure Code: P2185

POD: 218

Application: This control is the use of a reverse-air cleaned fabric filter to reduce PM emissions from waste streams. In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Reverse-air cleaning is performed by forcing clean air through the filters in the opposite direction of the dusty gas flow. The change in direction of the gas flow causes the bag to flex and crack the filter cake allowing for internal cake collection.

This control applies to cement manufacturing operations.

Affected SCC:

30500606 Mineral Products, Cement Manufacturing (Dry Process), Kilns
30500607 Cement Manufacturing (Dry Process), Raw Material Unloading
30500608 Cement Manufacturing (Dry Process), Raw Material Piles
30500609 Mineral Products, Cement Manufacturing (Dry Process), Primary Crushing
30500610 Mineral Products, Cement Manufacturing (Dry Process), Secondary Crushing
30500611 Mineral Products, Cement Manufacturing (Dry Process), Screening
30500612 Mineral Products, Cement Manufacturing (Dry Process), Raw Mat'l Transfer
30500613 Mineral Products, Cement Manufacturing (Dry Process), Raw Mat'l Grinding & Drying
30500614 Mineral Products, Cement Manufacturing (Dry Process), Clinker Cooler
30500615 Cement Manufacturing (Dry Process), Clinker Piles
30500616 Mineral Products, Cement Manufacturing (Dry Process), Clinker Transfer
30500617 Mineral Products, Cement Manufacturing (Dry Process), Clinker Grinding
30500618 Mineral Products, Cement Manufacturing (Dry Process), Cement Silos
30500619 Mineral Products, Cement Manufacturing (Dry Process), Cement Load Out
30500621 Cement Manufacturing (Dry Process), Pulverized Coal Kiln Feed Units
30500622 Cement Manufacturing (Dry Process), Preheater Kiln
30500623 Cement Manufacturing (Dry Process), Preheater/Precalciner Kiln
30500624 Cement Manufacturing (Dry Process), Raw Mill Feed Belt
30500626 Cement Manufacturing (Dry Process), Raw Mill Air Separator
30500699 Cement Manufacturing (Dry Process), Other Not Classified
30500706 Mineral Products, Cement Manufacturing (Wet Process), Kilns
30500707 Cement Manufacturing (Wet Process), Raw Material Unloading
30500708 Cement Manufacturing (Wet Process), Raw Material Piles
30500709 Cement Manufacturing (Wet Process), Primary Crushing
30500710 Cement Manufacturing (Wet Process), Secondary Crushing
30500712 Cement Manufacturing (Wet Process), Raw Material Transfer
30500714 Mineral Products, Cement Manufacturing (Wet Process), Clinker Cooler
30500716 Cement Manufacturing (Wet Process), Clinker Transfer
30500717 Cement Manufacturing (Wet Process), Clinker Grinding
30500718 Mineral Products, Cement Manufacturing (Wet Process), Cement Silos
30500719 Mineral Products, Cement Manufacturing (Wet Process), Cement Load Out
30500799 Mineral Products, Cement Manufacturing (Wet Process), Other Not Classified

AT-A-GLANCE TABLE FOR POINT SOURCES

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 99% from uncontrolled for both PM10 and PM2.5

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs for reverse-air cleaned systems are generated using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan,2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 2000). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$9 to \$84 per scfm
Typical value is \$34 per scfm

O&M Costs:

Range from \$6 to \$27 per scfm
Typical value is \$13 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). O&M costs were calculated for three model plants with flow rates of 25, 75 and 150 thousand acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust loading of 4.0 grains per cubic feet. The operating time was assumed to be 8760 hours per year. An average bag cost was estimated using the costs for standard bag

AT-A-GLANCE TABLE FOR POINT SOURCES

types. Capital recovery for the periodic replacement of bags was included in the O&M cost of the bags using a bag life of 2 years (EPA, 1998a). The following assumptions apply to the cost of utilities and disposal:

Electricity price	0 .0671	\$/kW-hr
Compressed air	0.25	\$/1000 scf
Dust disposal	25	\$/ton disposed

Note: All costs are in 1998 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$53 to \$337 per ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$148 per ton PM10 reduced. (1998\$)

Comments:

Status: Demonstrated	Last Reviewed: 2001
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Additional Information:

The largest source of particulate emissions at a cement plant is the kiln used to produce clinker. Cement kilns are rotary kilns, which are slowly rotating refractory-lined steel cylinders inclined slightly from the horizontal. Raw materials are fed into the top end of the kiln and spend several hours traversing the kiln. In wet process kilns (SCC 30500706), the raw materials are fed as a wet slurry. During this time, the raw materials are heated by a flame at the discharge end of the kiln. This heating dries the raw materials, converts limestone to lime, and promotes reaction between and fusion of the separate ingredients to form clinker. Clinker exiting the kiln is fed to a clinker cooler (SCC 30500714) for cooling before storage and further processing (STAPPA/ALAPCO, 1996).

The cost estimates assume a conventional design under typical operating conditions. The costs do not include any auxiliary equipment (EPA, 2000).

The capital cost for the reverse-jet cleaned fabric baghouse is based on information provided by a manufacturer (EPA, 2000). The capital cost includes only the purchased equipment cost.

Costs are primarily based on volumetric flow rate and the amount of PM in the waste stream. In general, a small unit controlling a low pollutant levels will not be as cost effective as a large unit controlling a high pollutant levels. (EPA, 2000)

Pollutants requiring a high level of control or the fabric filters to be constructed of special materials will increase the costs of the system (EPA, 1998a). The additional costs for controlling complex streams are not reflected in the estimates. For these systems, the capital cost could increase by as much as 40% and the O&M cost could increase by as much as 5%. (EPA, 2000)

In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Fabric filters may be in the form of sheets, cartridges, or bags, with many individual filter units together in a group. Bags are the most common type of filter. The dust cake that forms on the filter from the collected PM can significantly increase collection efficiency. (EPA, 2000)

Reverse-air cleaning is a popular filter cleaning method as it has been used extensively and improved over the years. It is a gentler but sometimes less effective clearing mechanism than mechanical shaking. Reverse-air cleaning is performed by forcing clean air through the filters in the

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opposite direction of the dusty gas flow. The change in direction of the gas flow causes the bag to flex and crack the filter cake allowing for internal cake collection (EPA, 2000).

The most common design is to have separate compartments within the fabric filter so that each can be isolated and cleaned separately while the others continue to treat the dusty gas. There are several methods of reversing the flow through the filters. One method of providing the reverse flow is by the use of a fan or cleaned gas from other compartments. Reverse-air cleaning only used alone in cases where the dust releases easily from the fabric. In many instances, reverse-air is used along with shaking, pulsing or sonic horns (EPA, 1998b).

Fabric filters are useful for collecting particles with resistivities either too low or too high for collection with electrostatic precipitators. Fabric filters are useful in controlling particulate matter less than or equal to 10 micrometers (μm) in diameter (PM₁₀) and particulate matter less than or equal to 2.5 μm in diameter (PM_{2.5}). Fabric filters may be good candidates for collecting fly ash from low-sulfur coals or containing high unburned carbon levels and are relatively difficult to collect with electrostatic precipitators. (EPA, 2000)

References:

EPA, 1998b: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

EPA, 1998a: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, Chapter 5, EPA 453/B-96-001, Research Triangle Park, NC. December 1998.

EPA, 2000: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Fabric Filter - Reverse-Air Cleaned Type," April 2000.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

STAPPA/ALAPCO, 1996: State and Territorial Air Pollution Program Administrators - Association of Local Air Pollution Control Officials, Controlling Particulate Matter Under the Clean Air Act: A Menu of Options, Washington, DC, July 1996.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Mineral Products - Cement Manufacture

Control Measure Name: Increased Monitoring Frequency (IMF) of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P3218

POD: 218

Application: This measure is to conduct improved monitoring for PM_{2.5} emissions at stationary sources. Improved monitoring in this case means increasing the monitoring frequency of electrostatic precipitators, scrubbers, and fabric filters from once per day to four times per hour, with no change in monitoring technique.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (Barr and Schaffner) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

305006** Mineral Products, Cement Manufacturing (Dry Process)

305007** Mineral Products, Cement Manufacturing (WetProcess)

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 6.5% for both PM₁₀ and PM_{2.5}

Equipment Life: Not applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs included the incremental record keeping and reporting associated with the increased monitoring frequency. Labor rates for 2003 were made that were obtained from the Bureau of Labor Statistics (labor rates include 140 percent overhead). The incremental costs included a one-time cost for development of the improved monitoring and recurring annual burden costs for incremental record keeping, reporting, and certification activities.

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$620 per ton PM reduced (2003\$).

Comments:

Status:

Last Reviewed: 2004

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM2.5 Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 2003.

BLS, 2003: Bureau of Labor Statistics, "Employer Costs for Employee Compensation – June 2003," Table 12, page 16, 2003.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Mineral Products - Cement Manufacture

Control Measure Name: CEM Upgrade and Increased Monitoring Frequency of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P4218

POD: 218

Application: This measure examines the impacts of improving the PM monitoring technique at units currently using an ESP, scrubber, or fabric filter. In this improved technique scenario, the monitoring technique is upgraded to a PM continuous emission monitor. This improved monitoring technique also results in an increase to the monitoring frequency because a PM CEMS can make a measurement every 7.5 minutes. The monitoring frequency increases from once per day to eight times per hour.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (see References) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

305006** Mineral Products, Cement Manufacturing (Dry Process)

305007** Mineral Products, Cement Manufacturing (WetProcess)

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 7.7% for both PM10 and PM2.5

Equipment Life: Unknown

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The total capital and annual operating costs for implementing an improved monitoring technique are calculated based on data from the EPA CEMS Cost Model and the PM CEMS Knowledge document. Labor rates in the EPA CEMS Cost Model are scaled to reflect 2003 labor rates (including 140 percent overhead) provided by the Bureau of Labor Statistics.

The cost effectiveness at a percent excess emission rate of 0.46 percent is \$5,200 per ton of PM2.5. This is based on a \$34 million capital investment cost, and a \$14 million total annualized cost when applied to 128 facilities.

Note: All costs are in 2003 dollars.

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Cost Effectiveness: The cost effectiveness used in AirControlNET is \$5,200 per ton PM reduced (2003\$).

Comments:

Status:

Last Reviewed: 2004

Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM_{2.5} Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 8, 2003.

EPA CEMS Cost Model, Version 3.0, U.S. Environmental Protection Agency.

EPA, 2000: U.S. Environmental Protection Agency, "Current Knowledge of Particulate Matter (PM) Continuous Emissions Monitoring," Chapter 9, PM CEMS Cost, September 8, 2000.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Mineral Products - Coal Cleaning

Control Measure Name: Fabric Filter (Pulse Jet Type)

Rule Name: Not Applicable

Pechan Measure Code: P2191

POD: 219

Application: This control is the addition of a pulse-jet cleaned fabric filter to reduce PM emissions from waste streams. In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Particulate-laden gas flows into the filter bag from the outside to the inside. The particles collected on the outside drop into a hopper below the fabric filter. During pulse-jet cleaning, a short burst of high pressure air is injected into the bags, dislodging the dust cake.

This control applies to coal cleaning PM10 and PM2.5 sources at mining operations.

Affected SCC:

30501001 Mineral Products, Coal Mining, Cleaning, & Mat'l Handling (See 305310), Fluidized Bed
30501002 Coal Mining, Cleaning, and Material Handling (See 305310), Flash or Suspension
30501004 Coal Mining, Cleaning, and Material Handling (See 305310), Rotary
30501007 Coal Mining, Cleaning, and Material Handling (See 305310), Screen
30501008 Coal Mining, Cleaning, and Material Handling (See 305310), Unloading
30501009 Coal Mining, Cleaning, and Material Handling (See 305310), Raw Coal Storage
30501010 Mineral Products, Coal Mining, Cleaning, and Material Handling (See 305310), Crushing
30501011 Coal Mining, Cleaning, and Material Handling (See 305310), Coal Transfer
30501012 Coal Mining, Cleaning, and Material Handling (See 305310), Screening
30501014 Coal Mining, Cleaning, and Material Handling (See 305310), Cleaned Coal Storage
30501015 Coal Mining, Cleaning, and Material Handling (See 305310), Loading
30501016 Coal Mining, Cleaning, and Material Handling (See 305310), Loading: Clean Coal
30501017 Coal Mining, Cleaning, and Material Handling (See 305310), Secondary Crushing
30501021 Coal Mining, Cleaning, and Material Handling (See 305310), Overburden Removal
30501022 Coal Mining, Cleaning, and Material Handling (See 305310), Drilling/Blasting
30501023 Coal Mining, Cleaning, and Material Handling (See 305310), Loading
30501024 Coal Mining, Cleaning, and Material Handling (See 305310), Hauling
30501030 Coal Mining, Cleaning, and Material Handling (See 305310), Topsoil Removal
30501031 Coal Mining, Cleaning, and Material Handling (See 305310), Scrapers: Travel Mode
30501032 Coal Mining, Cleaning, and Material Handling (See 305310), Topsoil Unloading
30501033 Coal Mining, Cleaning, and Material Handling (See 305310), Overburden
30501036 Coal Mining, Cleaning, & Mat'l Handling (See 305310), Dragline-Overburden Removal
30501037 Coal Mining, Cleaning, and Material Handling (See 305310), Truck Loading: Overburden
30501038 Coal Mining, Cleaning, and Material Handling (See 305310), Truck Loading: Coal
30501039 Coal Mining, Cleaning, and Material Handling (See 305310), Hauling: Haul Trucks
30501040 Coal Mining, Cleaning, & Mat'l Handling (See 305310), Truck Unloading-End Dump-Coal
30501041 Coal Mining, Cleaning, & Mat'l Handling (See 305310), Truck Unload-Bottom Dump-Coal
30501043 Coal Mining, Cleaning, and Material Handling (See 305310), Open Storage Pile: Coal
30501044 Coal Mining, Cleaning, and Material Handling (See 305310), Train Loading: Coal
30501045 Coal Mining, Cleaning, and Material Handling (See 305310), Bulldozing: Overburden
30501046 Coal Mining, Cleaning, and Material Handling (See 305310), Bulldozing: Coal
30501047 Coal Mining, Cleaning, and Material Handling (See 305310), Grading
30501049 Coal Mining, Cleaning, and Mat'l Handling (See 305310), Wind Erosion-Exposed Areas
30501050 Coal Mining, Cleaning & Mat'l Handling (See 305310), Vehicles-Light/Med.
30501051 Coal Mining, Cleaning & Mat'l Handling (See 305310), Surface Mining

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30501090 Coal Mining, Cleaning, and Material Handling (See 305310), Haul Roads: General
30501099 Coal Mining, Cleaning, and Material Handling (See 305310), Other Not Classified

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 99% from uncontrolled for both PM10 and PM2.5

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs for pulse-jet cleaned systems are generated using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan, 2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 2000). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$6 to \$26 per scfm
Typical value is \$13 per scfm

O&M Costs:

Range from \$5 to \$24 per scfm
Typical value is \$11 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). O&M costs were calculated for three model plants with flow rates of 25, 75 and 150 thousand acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust

AT-A-GLANCE TABLE FOR POINT SOURCES

loading of 4.0 grains per cubic feet. The operating time was assumed to be 8760 hours per year. An average bag cost was estimated using the costs for standard bag types. Capital recovery for the periodic replacement of bags was included in the O&M cost of the bags using a bag life of 2 years (EPA, 1998a). The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.0671	\$/kW-hr
Compressed air	0.25	\$/1000 scf
Dust disposal	25	\$/ton disposed

Note: All costs are in 1998 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$42 to \$266 per ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$117 per ton PM10 reduced. (1998\$)

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

Coal mining, cleaning and material handling (305010) consists of the preparation and handling of coal to upgrade its value. For the purpose of this study, thermal dryers, pneumatic coal cleaning and truck/vehicle travel are the sources considered. Thermal dryers are used at the end of the series of cleaning operations to remove moisture from coal, thereby reducing freezing problems and weight, and increasing the heating value. The major portion of water is removed by the use of screens, thickeners, and cyclones. The coal is then dried in a thermal dryer. Particulate emissions result from the entrainment of fine coal particles during the thermal drying process (EPA, 1995). Pneumatic coal-cleaning equipment classifies bituminous coal by size or separates bituminous coal from refuse by application of air streams. Fugitive PM emissions result when haul trucks or other vehicles travel on unpaved roads or surfaces.

The cost estimates assume a conventional design under typical operating conditions and do not include auxiliary equipment such as fans and ductwork. The costs for pulse-jet cleaned systems are generated using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a).

Costs are primarily based on volumetric flow rate and the amount of PM in the waste stream. In general, a small unit controlling a low pollutant levels will not be as cost effective as a large unit controlling a high pollutant levels. (EPA, 2000)

Pollutants requiring a high level of control or the fabric filters to be constructed of special materials will increase the costs of the system (EPA, 1998a). The additional costs for controlling complex waste streams are not included in the estimates. For these systems, the capital cost could increase by as much as 75% and the operational and maintenance (O&M) cost could increase by as much as 20% (EPA, 2000).

In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Fabric filters may be in the form of sheets, cartridges, or bags, with many individual filter units together in a group. Bags are the most common type of filter. The dust cake that forms on the filter from the collected PM can significantly increase collection efficiency. (EPA, 2000)

AT-A-GLANCE TABLE FOR POINT SOURCES

Pulse-jet cleaning of fabric filters is a relatively new type of fabric filter, as they have only been used for the past 30 years. This cleaning mechanism has grown in popularity because it can treat high dust loadings, operate at constant pressure drop, and occupy less space than other types of fabric filters (EPA, 2000). Particulate-laden gas flows into the bag. The gas flows from the outside to the inside of the bags, and then out the gas exhaust. The particles collected on the outside drop into a hopper below the fabric filter (EPA, 1998b).

During pulse-jet cleaning, a short burst of high pressure air is injected into the bags (EPA, 1998b). The pulse is blown through a venturi nozzle at the top of the bags and establishes a shock wave that continues onto the bottom of the bag. The wave flexes the fabric dislodging the dust cake.

There are several unique attributes of pulse-jet cleaning. The cleaning pulse is very brief allowing the flow of dusty gas to continue during cleaning. The bags not being cleaned continue to filter, taking on extra duty from the bags being cleaned (EPA, 2000). Pulse-jet cleaning is more intense and occurs with greater frequency than the other fabric filter cleaning methods. The cleaning dislodges nearly all of the dust cake each time the bag is pulsed. Pulse-jet filters, as a result, do not rely on a dust cake to provide filtration. Felted (non-woven) fabrics are used in these types of filters because they do not require a dust cake. Also it has been found that woven fabrics used with pulse-jet cleaning leak dust after they are cleaned (EPA, 1998b).

Since bags cleaned by the pulse-jet method do not need to be isolated for cleaning, pulsejet cleaned fabric filters do not need extra compartments to maintain adequate filtration during cleaning. Also, because of the intense and frequent nature of the cleaning, they can treat higher gas flow rates with higher dust loadings. Consequently, fabric filters cleaned by the pulse-jet method can be smaller than other filters in the treatment of the same amount of gas and dust, making higher gas-to-cloth ratios achievable (EPA, 1998b).

Fabric filters are useful for collecting particles with resistivities either too low or too high for collection with electrostatic precipitators. Fabric filters are useful in controlling particulate matter less than or equal to 10 micrometers (μm) in diameter (PM₁₀) and particulate matter less than or equal to 2.5 μm in diameter (PM_{2.5}). Fabric filters may be good candidates for collecting fly ash from low-sulfur coals or containing high unburned carbon levels and are relatively difficult to collect with electrostatic precipitators. (EPA, 2000)

References:

EPA, 1995: U.S. Environmental Protection Agency, "Compilation of Air Pollutant Emission Factors," AP-42, Volume I, Fifth Edition, Research Triangle Park, NC, January 1995

EPA, 1998a: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, Chapter 5, EPA 453/B-96-001, Research Triangle Park, NC. December 1998.

EPA, 1998b: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

EPA, 2000: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Fabric Filter - Pulse-Jet Cleaned Type," April 2000.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Mineral Products - Coal Cleaning

Control Measure Name: Fabric Filter (Mech. Shaker Type)

Rule Name: Not Applicable

Pechan Measure Code: P2192

POD: 219

Application: This control is the addition of a mechanical shaker type fabric filter to reduce PM emissions. In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. The gas stream is drawn from beneath a cell plate in the floor and into the filter bags. The gas proceeds from the inside to the outside of the filter bags. The particles collect on the inside of the bags, forming a filter cake. In mechanical shaking units, the tops of bags are attached to a shaker bar, moved briskly to clean the bags.

This control applies to coal cleaning at coal mining operations. Coal mining, cleaning and material handling (305010) consists of the preparation and handling of coal to upgrade its value.

Affected SCC:

30501001 Mineral Products, Coal Mining, Cleaning, & Mat'l Handling (See 305310), Fluidized Bed
30501002 Coal Mining, Cleaning, and Material Handling (See 305310), Flash or Suspension
30501004 Coal Mining, Cleaning, and Material Handling (See 305310), Rotary
30501007 Coal Mining, Cleaning, and Material Handling (See 305310), Screen
30501008 Coal Mining, Cleaning, and Material Handling (See 305310), Unloading
30501009 Coal Mining, Cleaning, and Material Handling (See 305310), Raw Coal Storage
30501010 Mineral Products, Coal Mining, Cleaning, and Material Handling (See 305310), Crushing
30501011 Coal Mining, Cleaning, and Material Handling (See 305310), Coal Transfer
30501012 Coal Mining, Cleaning, and Material Handling (See 305310), Screening
30501014 Coal Mining, Cleaning, and Material Handling (See 305310), Cleaned Coal Storage
30501015 Coal Mining, Cleaning, and Material Handling (See 305310), Loading
30501016 Coal Mining, Cleaning, and Material Handling (See 305310), Loading: Clean Coal
30501017 Coal Mining, Cleaning, and Material Handling (See 305310), Secondary Crushing
30501021 Coal Mining, Cleaning, and Material Handling (See 305310), Overburden Removal
30501022 Coal Mining, Cleaning, and Material Handling (See 305310), Drilling/Blasting
30501023 Coal Mining, Cleaning, and Material Handling (See 305310), Loading
30501024 Coal Mining, Cleaning, and Material Handling (See 305310), Hauling
30501030 Coal Mining, Cleaning, and Material Handling (See 305310), Topsoil Removal
30501031 Coal Mining, Cleaning, and Material Handling (See 305310), Scrapers: Travel Mode
30501032 Coal Mining, Cleaning, and Material Handling (See 305310), Topsoil Unloading
30501033 Coal Mining, Cleaning, and Material Handling (See 305310), Overburden
30501036 Coal Mining, Cleaning, & Mat'l Handling (See 305310), Dragline-Overburden Removal
30501037 Coal Mining, Cleaning, and Material Handling (See 305310), Truck Loading: Overburden
30501038 Coal Mining, Cleaning, and Material Handling (See 305310), Truck Loading: Coal
30501039 Coal Mining, Cleaning, and Material Handling (See 305310), Hauling: Haul Trucks
30501040 Coal Mining, Cleaning, & Mat'l Handling (See 305310), Truck Unloading-End Dump-Coal
30501041 Coal Mining, Cleaning, & Mat'l Handling (See 305310), Truck Unload-Bottom Dump-Coal
30501043 Coal Mining, Cleaning, and Material Handling (See 305310), Open Storage Pile: Coal
30501044 Coal Mining, Cleaning, and Material Handling (See 305310), Train Loading: Coal
30501045 Coal Mining, Cleaning, and Material Handling (See 305310), Bulldozing: Overburden
30501046 Coal Mining, Cleaning, and Material Handling (See 305310), Bulldozing: Coal
30501047 Coal Mining, Cleaning, and Material Handling (See 305310), Grading

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30501049 Coal Mining, Cleaning, and Mat'l Handling (See 305310), Wind Erosion-Exposed Areas
 30501050 Coal Mining, Cleaning & Mat'l Handling (See 305310), Vehicles-Light/Med.
 30501051 Coal Mining, Cleaning & Mat'l Handling (See 305310), Surface Mining
 30501090 Coal Mining, Cleaning, and Material Handling (See 305310), Haul Roads: General
 30501099 Coal Mining, Cleaning, and Material Handling (See 305310), Other Not Classified

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 99% from uncontrolled for both PM10 and PM2.5

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs for mechanical shaker cleaned systems are generated using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan,2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 2000).. Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$8 to \$71 per scfm
 Typical value is \$29 per scfm

O&M Costs:

Range from \$4 to \$24 per scfm
 Typical value is \$11 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a).

AT-A-GLANCE TABLE FOR POINT SOURCES

O&M costs were calculated for three model plants with flow rates of 25, 75 and 150 thousand acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust loading of 4.0 grains per cubic feet. The operating time was assumed to be 8760 hours per year. An average bag cost was estimated using the costs for standard bag types. Capital recovery for the periodic replacement of bags was included in the O&M cost of the bags using a bag life of 2 years (EPA, 1998a). The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.0671	\$/kW-hr
Compressed air	0.25	\$/1000 scf
Dust disposal	25	\$/ton disposed

Note: All costs are in 1998 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$37 to \$303 per ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$126 per ton PM10 reduced. (1998\$)

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

Cost estimates assume a conventional design under typical operating conditions. The costs do not include auxiliary equipment such as fans and ductwork. (EPA, 2000)

Costs are primarily based on volumetric flow rate and the amount of PM in the waste stream. In general, a small unit controlling a low pollutant levels will not be as cost effective as a large unit controlling a high pollutant levels. (EPA, 2000)

Pollutants requiring a high level of control or the fabric filters to be constructed of special materials will increase the costs of the system (EPA, 1998a). The additional costs for controlling complex waste streams are not included in the estimates. For these systems, the capital cost could increase by as much as 30% and the O&M cost could increase by as much as 7%.

In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Fabric filters may be in the form of sheets, cartridges, or bags, with many individual filter units together in a group. Bags are the most common type of filter. The dust cake that forms on the filter from the collected PM can significantly increase collection efficiency. (EPA, 2000)

Mechanical shaking is a popular cleaning method because it is both simple and effective. In typical operation, dusty gas enters an inlet pipe to the fabric filter and very large particles are removed using a baffle plate fall into the hopper. The gas stream is drawn from beneath a cell plate in the floor and into the filter bags (EPA, 2000). The gas proceeds from the inside to the outside of the filter bags. The particles collect on the inside of the bags, forming a filter cake. In mechanical shaking units, the tops of bags are attached to a shaker bar, moved briskly (usually in a horizontal direction) to clean the bags. The shaker bars are operated by mechanical motors or by hand (EPA, 1998b)..

Fabric filters are useful for collecting particles with resistivities either too low or too high for collection

AT-A-GLANCE TABLE FOR POINT SOURCES

with electrostatic precipitators. Fabric filters are useful in controlling particulate matter less than or equal to 10 micrometers (μm) in diameter (PM10) and particulate matter less than or equal to 2.5 μm in diameter (PM2.5). Fabric filters may be good candidates for collecting fly ash from low-sulfur coals or containing high unburned carbon levels and are relatively difficult to collect with electrostatic precipitators. (EPA, 2000)

References:

EPA, 1998a: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, Chapter 5, EPA 453/B-96-001, Research Triangle Park, NC. December 1998.

EPA, 1998b: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

EPA, 2000: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Fabric Filter - Mechanical Shaker Cleaned Type," August 2000.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Mineral Products - Coal Cleaning

Control Measure Name: Paper/Nonwoven Filters - Cartridge Collector Type

Rule Name: Not Applicable

Pechan Measure Code: P2193

POD: 219

Application: This control is the use of paper or non-woven filters (cartridge collector type) to reduce PM emissions. The waste gas stream is passed through the fibrous filter media causing PM in the gas stream to be collected on the media by sieving and other mechanisms.

This control measure applies to coal cleaning processes at coal mining operations.

Affected SCC:

30501001 Mineral Products, Coal Mining, Cleaning, & Mat'l Handling (See 305310), Fluidized Bed
30501002 Coal Mining, Cleaning, and Material Handling (See 305310), Flash or Suspension
30501004 Coal Mining, Cleaning, and Material Handling (See 305310), Rotary
30501007 Coal Mining, Cleaning, and Material Handling (See 305310), Screen
30501008 Coal Mining, Cleaning, and Material Handling (See 305310), Unloading
30501009 Coal Mining, Cleaning, and Material Handling (See 305310), Raw Coal Storage
30501010 Mineral Products, Coal Mining, Cleaning, and Material Handling (See 305310), Crushing
30501011 Coal Mining, Cleaning, and Material Handling (See 305310), Coal Transfer
30501012 Coal Mining, Cleaning, and Material Handling (See 305310), Screening
30501014 Coal Mining, Cleaning, and Material Handling (See 305310), Cleaned Coal Storage
30501015 Coal Mining, Cleaning, and Material Handling (See 305310), Loading
30501016 Coal Mining, Cleaning, and Material Handling (See 305310), Loading: Clean Coal
30501017 Coal Mining, Cleaning, and Material Handling (See 305310), Secondary Crushing
30501021 Coal Mining, Cleaning, and Material Handling (See 305310), Overburden Removal
30501022 Coal Mining, Cleaning, and Material Handling (See 305310), Drilling/Blasting
30501023 Coal Mining, Cleaning, and Material Handling (See 305310), Loading
30501024 Coal Mining, Cleaning, and Material Handling (See 305310), Hauling
30501030 Coal Mining, Cleaning, and Material Handling (See 305310), Topsoil Removal
30501031 Coal Mining, Cleaning, and Material Handling (See 305310), Scrapers: Travel Mode
30501032 Coal Mining, Cleaning, and Material Handling (See 305310), Topsoil Unloading
30501033 Coal Mining, Cleaning, and Material Handling (See 305310), Overburden
30501036 Coal Mining, Cleaning, & Mat'l Handling (See 305310), Dragline-Overburden Removal
30501037 Coal Mining, Cleaning, and Material Handling (See 305310), Truck Loading: Overburden
30501038 Coal Mining, Cleaning, and Material Handling (See 305310), Truck Loading: Coal
30501039 Coal Mining, Cleaning, and Material Handling (See 305310), Hauling: Haul Trucks
30501040 Coal Mining, Cleaning, & Mat'l Handling (See 305310), Truck Unloading-End Dump-Coal
30501041 Coal Mining, Cleaning, & Mat'l Handling (See 305310), Truck Unload-Bottom Dump-Coal
30501043 Coal Mining, Cleaning, and Material Handling (See 305310), Open Storage Pile: Coal
30501044 Coal Mining, Cleaning, and Material Handling (See 305310), Train Loading: Coal
30501045 Coal Mining, Cleaning, and Material Handling (See 305310), Bulldozing: Overburden
30501046 Coal Mining, Cleaning, and Material Handling (See 305310), Bulldozing: Coal
30501047 Coal Mining, Cleaning, and Material Handling (See 305310), Grading
30501049 Coal Mining, Cleaning, and Mat'l Handling (See 305310), Wind Erosion-Exposed Areas
30501050 Coal Mining, Cleaning & Mat'l Handling (See 305310), Vehicles-Light/Med.
30501051 Coal Mining, Cleaning & Mat'l Handling (See 305310), Surface Mining
30501090 Coal Mining, Cleaning, and Material Handling (See 305310), Haul Roads: General
30501099 Coal Mining, Cleaning, and Material Handling (See 305310), Other Not Classified

AT-A-GLANCE TABLE FOR POINT SOURCES

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 99% from uncontrolled for both PM10 and PM2.5

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs are generated using EPA's cost-estimating spreadsheets for fabric filters (EPA, 1998a). Costs are primarily driven by the waste stream volumetric flow rate and pollutant loading. When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan,2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 2000). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$7 to \$13 per scfm

Typical value is \$9 per scfm

O&M Costs:

Range from \$9 to \$25 per scfm

Typical value is \$14 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). O&M costs were calculated for three model plants with flow rates of 25, 75 and 150 thousand acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust loading of 4.0 grains per cubic feet. The operating time was assumed to be 8760 hours per year. An average cartridge cost was estimated using the costs for standard

AT-A-GLANCE TABLE FOR POINT SOURCES

cartridge types. Capital recovery for the periodic replacement of cartridges was included in the O&M cost of the cartridges using a cartridge life of 2 years (EPA, 1998a). The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.0671	\$/kW-hr
Compressed air	0.25	\$/1000 scf
Dust disposal	25	\$/ton disposed

Note: All costs are in 1998 dollars.

Cost Effectiveness: When stack flow is available, the cost effectiveness varies from \$85 to \$256 per ton PM₁₀ removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$142 per ton PM₁₀ reduced. (1998\$)

Comments:

Status: Demonstrated	Last Reviewed: 2001
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Additional Information:

Coal mining, cleaning and material handling (305010) consists of the preparation and handling of coal to upgrade its value. For the purpose of this study, thermal dryers, pneumatic coal cleaning and truck/vehicle travel are the sources considered. Thermal dryers are used at the end of the series of cleaning operations to remove moisture from coal, thereby reducing freezing problems and weight, and increasing the heating value. The major portion of water is removed by the use of screens, thickeners, and cyclones. The coal is then dried in a thermal dryer. Particulate emissions result from the entrainment of fine coal particles during the thermal drying process (EPA, 1995). Pneumatic coal-cleaning equipment classifies bituminous coal by size or separates bituminous coal from refuse by application of air streams. Fugitive PM emissions result when haul trucks or other vehicles travel on unpaved roads or surfaces.

The cost estimates assume a conventional design under typical operating conditions. Auxiliary equipment, such as fans and ductwork, is not included (EPA, 2000). Pollutants that require an unusually high level of control or that require the filter media or the unit itself to be constructed of special materials, such as Nomex® or stainless steel, will increase the costs of the system (EPA, 1998a). The additional costs for controlling more complex waste streams are not reflected in the estimates given below. For these types of systems, the capital cost could increase by as much as 75% and the O&M cost could increase by as much as 10%. In general, a small unit controlling a low pollutant loading will not be as cost effective as a large unit controlling a high pollutant loading (EPA, 2000).

Cartridge filters contain either a paper or nonwoven fibrous filter media (EPA, 2000). Paper media is generally made of materials such as cellulose and fiberglass. The dust cake that forms on the filter media from the collected PM can significantly increase collection efficiency (EPA, 1998b).

In general, the filter media is pleated to provide a larger surface area to volume flow rate. Close pleating, however, can cause PM to bridge the pleat bottom, effectively reducing the surface collection area (EPA, 1998b). Corrugated aluminum separators are used to prevent the pleats from collapsing (Heumann, 1997). There are variety of cartridge designs and dimensions. Typical designs include flat panels, V-shaped packs or cylindrical packs (Heumann, 1997). For certain applications, two cartridges may be placed in series.

Cartridge collectors are useful for collecting particles with resistivities either too low or too high for

AT-A-GLANCE TABLE FOR POINT SOURCES

collection with electrostatic precipitators (STAPPA/ALAPCO, 1996). For similar air flow rates, cartridge collectors are compact in size compared to traditional bag

References:

EPA, 1995: U.S. Environmental Protection Agency, "Compilation of Air Pollutant Emission Factors," AP-42, Volume I, Fifth Edition, Research Triangle Park, NC, January 1995.

EPA, 1998b: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, Chapter 5, EPA 453/B-96-001, Research Triangle Park, NC. December 1998.

EPA, 1998a: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

EPA, 2000: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Cartridge Collector with Pulse-Jet Cleaning," April 2000.

Heumann, 1997: W. L. Heumann, "Industrial Air Pollution Control Systems," McGraw Hill Publishers, Inc., Washington, D.C., 1997.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

STAPPA/ALAPCO, 1996: State and Territorial Air Pollution Program Administrators and Association of Local Air Pollution Control Officials, "Controlling Particulate Matter Under the Clean Air Act: A Menu of Options," July 1996.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Mineral Products - Coal Cleaning

Control Measure Name: Fabric Filter (Reverse-Air Cleaned Type)

Rule Name: Not Applicable

Pechan Measure Code: P2194

POD: 219

Application: This control is the use of a reverse-air cleaned fabric filter to reduce PM emissions from waste streams. In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Reverse-air cleaning is performed by forcing clean air through the filters in the opposite direction of the dusty gas flow. The change in direction of the gas flow causes the bag to flex and crack the filter cake allowing for internal cake collection.

This control applies to coal cleaning at coal mining operations. .

Affected SCC:

30501001 Mineral Products, Coal Mining, Cleaning, & Mat'l Handling (See 305310), Fluidized Bed
30501002 Coal Mining, Cleaning, and Material Handling (See 305310), Flash or Suspension
30501004 Coal Mining, Cleaning, and Material Handling (See 305310), Rotary
30501007 Coal Mining, Cleaning, and Material Handling (See 305310), Screen
30501008 Coal Mining, Cleaning, and Material Handling (See 305310), Unloading
30501009 Coal Mining, Cleaning, and Material Handling (See 305310), Raw Coal Storage
30501010 Mineral Products, Coal Mining, Cleaning, and Material Handling (See 305310), Crushing
30501011 Coal Mining, Cleaning, and Material Handling (See 305310), Coal Transfer
30501012 Coal Mining, Cleaning, and Material Handling (See 305310), Screening
30501014 Coal Mining, Cleaning, and Material Handling (See 305310), Cleaned Coal Storage
30501015 Coal Mining, Cleaning, and Material Handling (See 305310), Loading
30501016 Coal Mining, Cleaning, and Material Handling (See 305310), Loading: Clean Coal
30501017 Coal Mining, Cleaning, and Material Handling (See 305310), Secondary Crushing
30501021 Coal Mining, Cleaning, and Material Handling (See 305310), Overburden Removal
30501022 Coal Mining, Cleaning, and Material Handling (See 305310), Drilling/Blasting
30501023 Coal Mining, Cleaning, and Material Handling (See 305310), Loading
30501024 Coal Mining, Cleaning, and Material Handling (See 305310), Hauling
30501030 Coal Mining, Cleaning, and Material Handling (See 305310), Topsoil Removal
30501031 Coal Mining, Cleaning, and Material Handling (See 305310), Scrapers: Travel Mode
30501032 Coal Mining, Cleaning, and Material Handling (See 305310), Topsoil Unloading
30501033 Coal Mining, Cleaning, and Material Handling (See 305310), Overburden
30501036 Coal Mining, Cleaning, & Mat'l Handling (See 305310), Dragline-Overburden Removal
30501037 Coal Mining, Cleaning, and Material Handling (See 305310), Truck Loading: Overburden
30501038 Coal Mining, Cleaning, and Material Handling (See 305310), Truck Loading: Coal
30501039 Coal Mining, Cleaning, and Material Handling (See 305310), Hauling: Haul Trucks
30501040 Coal Mining, Cleaning, & Mat'l Handling (See 305310), Truck Unloading-End Dump-Coal
30501041 Coal Mining, Cleaning, & Mat'l Handling (See 305310), Truck Unload-Bottom Dump-Coal
30501043 Coal Mining, Cleaning, and Material Handling (See 305310), Open Storage Pile: Coal
30501044 Coal Mining, Cleaning, and Material Handling (See 305310), Train Loading: Coal
30501045 Coal Mining, Cleaning, and Material Handling (See 305310), Bulldozing: Overburden
30501046 Coal Mining, Cleaning, and Material Handling (See 305310), Bulldozing: Coal
30501047 Coal Mining, Cleaning, and Material Handling (See 305310), Grading
30501049 Coal Mining, Cleaning, and Mat'l Handling (See 305310), Wind Erosion-Exposed Areas
30501050 Coal Mining, Cleaning & Mat'l Handling (See 305310), Vehicles-Light/Med.
30501051 Coal Mining, Cleaning & Mat'l Handling (See 305310), Surface Mining

AT-A-GLANCE TABLE FOR POINT SOURCES

30501090 Coal Mining, Cleaning, and Material Handling (See 305310), Haul Roads: General
 30501099 Coal Mining, Cleaning, and Material Handling (See 305310), Other Not Classified

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 99% from uncontrolled for both PM10 and PM2.5

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs for reverse-air cleaned systems are generated using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan, 2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 2000). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$9 to \$84 per scfm
 Typical value is \$34 per scfm

O&M Costs:

Range from \$6 to \$27 per scfm
 Typical value is \$13 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). O&M costs were calculated for three model plants with flow rates of 25, 75 and 150 thousand acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust

AT-A-GLANCE TABLE FOR POINT SOURCES

loading of 4.0 grains per cubic feet. The operating time was assumed to be 8760 hours per year. An average bag cost was estimated using the costs for standard bag types. Capital recovery for the periodic replacement of bags was included in the O&M cost of the bags using a bag life of 2 years (EPA, 1998a). The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.0671	\$/kW-hr
Compressed air	0.25	\$/1000 scf
Dust disposal	25	\$/ton disposed

Note: All costs are in 1998 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$53 to \$337 per ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$148 per ton PM10 reduced. (1998\$)

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

Coal mining, cleaning and material handling (305010) consists of the preparation and handling of coal to upgrade its value. For the purpose of this study, thermal dryers, pneumatic coal cleaning and truck/vehicle travel are the sources considered. Thermal dryers are used at the end of the series of cleaning operations to remove moisture from coal, thereby reducing freezing problems and weight, and increasing the heating value. The major portion of water is removed by the use of screens, thickeners, and cyclones. The coal is then dried in a thermal dryer. Particulate emissions result from the entrainment of fine coal particles during the thermal drying process (EPA, 1995). Pneumatic coal-cleaning equipment classifies bituminous coal by size or separates bituminous coal from refuse by application of air streams. Fugitive PM emissions result when haul trucks or other vehicles travel on unpaved roads or surfaces.

The cost estimates assume a conventional design under typical operating conditions. The costs do not include any auxiliary equipment (EPA, 2000).

The capital cost for the reverse-jet cleaned fabric baghouse is based on information provided by a manufacturer (EPA, 2000). The capital cost includes only the purchased equipment cost.

Costs are primarily based on volumetric flow rate and the amount of PM in the waste stream. In general, a small unit controlling a low pollutant levels will not be as cost effective as a large unit controlling a high pollutant levels. (EPA, 2000)

Pollutants requiring a high level of control or the fabric filters to be constructed of special materials will increase the costs of the system (EPA, 1998a). The additional costs for controlling complex streams are not reflected in the estimates. For these systems, the capital cost could increase by as much as 40% and the O&M cost could increase by as much as 5%. (EPA, 2000)

In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Fabric filters may be in the form of sheets, cartridges, or bags, with many individual filter units together in a group. Bags are the most common type of filter. The dust cake that forms on the filter from the collected PM can significantly increase collection efficiency. (EPA, 2000)

AT-A-GLANCE TABLE FOR POINT SOURCES

Reverse-air cleaning is a popular filter cleaning method as it has been used extensively and improved over the years. It is a gentler but sometimes less effective clearing mechanism than mechanical shaking. Reverse-air cleaning is performed by forcing clean air through the filters in the opposite direction of the dusty gas flow. The change in direction of the gas flow causes the bag to flex and crack the filter cake allowing for internal cake collection (EPA, 2000).

The most common design is to have separate compartments within the fabric filter so that each can be isolated and cleaned separately while the others continue to treat the dusty gas. There are several methods of reversing the flow through the filters. One method of providing the reverse flow is by the use of a fan or cleaned gas from other compartments. Reverse-air cleaning only used alone in cases where the dust releases easily from the fabric. In many instances, reverse-air is used along with shaking, pulsing or sonic horns (EPA, 1998b).

Fabric filters are useful for collecting particles with resistivities either too low or too high for collection with electrostatic precipitators. Fabric filters are useful in controlling particulate matter less than or equal to 10 micrometers (μm) in diameter (PM10) and particulate matter less than or equal to 2.5 μm in diameter (PM2.5). Fabric filters may be good candidates for collecting fly ash from low-sulfur coals or containing high unburned carbon levels and are relatively difficult to collect with electrostatic precipitators. (EPA, 2000)

References:

EPA, 1995: U.S. Environmental Protection Agency, "Compilation of Air Pollutant Emission Factors," AP-42, Volume I, Fifth Edition, Research Triangle Park, NC, January 1995.

EPA, 1998b: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

EPA, 1998a: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, Chapter 5, EPA 453/B-96-001, Research Triangle Park, NC. December 1998.

EPA, 2000: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Fabric Filter - Reverse-Air Cleaned Type," April 2000.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Mineral Products - Coal Cleaning

Control Measure Name: Venturi Scrubber

Rule Name: Not Applicable

Pechan Measure Code: P2195

POD: 219

Application: The control is the use of a venturi scrubber to reduce PM emissions. A scrubber is a type of technology that removes air pollutants by inertial and diffusional interception. A venturi scrubber accelerates the waste gas stream to atomize the scrubbing liquid and to improve gas-liquid contact.

This control applies to coal cleaning processes at coal mining operations. Coal mining, cleaning and material handling (305010) consists of the preparation and handling of coal to upgrade its value. For the purpose of this study, thermal dryers, pneumatic coal cleaning and truck/vehicle travel are the sources considered.

Affected SCC:

30501001 Mineral Products, Coal Mining, Cleaning, & Mat'l Handling (See 305310), Fluidized Bed
30501002 Coal Mining, Cleaning, and Material Handling (See 305310), Flash or Suspension
30501004 Coal Mining, Cleaning, and Material Handling (See 305310), Rotary
30501007 Coal Mining, Cleaning, and Material Handling (See 305310), Screen
30501008 Coal Mining, Cleaning, and Material Handling (See 305310), Unloading
30501009 Coal Mining, Cleaning, and Material Handling (See 305310), Raw Coal Storage
30501010 Mineral Products, Coal Mining, Cleaning, and Material Handling (See 305310), Crushing
30501011 Coal Mining, Cleaning, and Material Handling (See 305310), Coal Transfer
30501012 Coal Mining, Cleaning, and Material Handling (See 305310), Screening
30501014 Coal Mining, Cleaning, and Material Handling (See 305310), Cleaned Coal Storage
30501015 Coal Mining, Cleaning, and Material Handling (See 305310), Loading
30501016 Coal Mining, Cleaning, and Material Handling (See 305310), Loading: Clean Coal
30501017 Coal Mining, Cleaning, and Material Handling (See 305310), Secondary Crushing
30501021 Coal Mining, Cleaning, and Material Handling (See 305310), Overburden Removal
30501022 Coal Mining, Cleaning, and Material Handling (See 305310), Drilling/Blasting
30501023 Coal Mining, Cleaning, and Material Handling (See 305310), Loading
30501024 Coal Mining, Cleaning, and Material Handling (See 305310), Hauling
30501030 Coal Mining, Cleaning, and Material Handling (See 305310), Topsoil Removal
30501031 Coal Mining, Cleaning, and Material Handling (See 305310), Scrapers: Travel Mode
30501032 Coal Mining, Cleaning, and Material Handling (See 305310), Topsoil Unloading
30501033 Coal Mining, Cleaning, and Material Handling (See 305310), Overburden
30501036 Coal Mining, Cleaning, & Mat'l Handling (See 305310), Dragline-Overburden Removal
30501037 Coal Mining, Cleaning, and Material Handling (See 305310), Truck Loading: Overburden
30501038 Coal Mining, Cleaning, and Material Handling (See 305310), Truck Loading: Coal
30501039 Coal Mining, Cleaning, and Material Handling (See 305310), Hauling: Haul Trucks
30501040 Coal Mining, Cleaning, & Mat'l Handling (See 305310), Truck Unloading-End Dump-Coal
30501041 Coal Mining, Cleaning, & Mat'l Handling (See 305310), Truck Unload-Bottom Dump-Coal
30501043 Coal Mining, Cleaning, and Material Handling (See 305310), Open Storage Pile: Coal
30501044 Coal Mining, Cleaning, and Material Handling (See 305310), Train Loading: Coal
30501045 Coal Mining, Cleaning, and Material Handling (See 305310), Bulldozing: Overburden
30501046 Coal Mining, Cleaning, and Material Handling (See 305310), Bulldozing: Coal
30501047 Coal Mining, Cleaning, and Material Handling (See 305310), Grading
30501049 Coal Mining, Cleaning, and Mat'l Handling (See 305310), Wind Erosion-Exposed Areas
30501050 Coal Mining, Cleaning & Mat'l Handling (See 305310), Vehicles-Light/Med.

AT-A-GLANCE TABLE FOR POINT SOURCES

30501051 Coal Mining, Cleaning & Mat'l Handling (See 305310), Surface Mining
 30501090 Coal Mining, Cleaning, and Material Handling (See 305310), Haul Roads: General
 30501099 Coal Mining, Cleaning, and Material Handling (See 305310), Other Not Classified

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: PM10 control efficiency is 99% from uncontrolled; PM2.5 control efficiency is 98% from uncontrolled

Equipment Life: 10 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The following are cost ranges for venturi wet scrubbers, developed using EPA cost-estimating spreadsheets (EPA, 1996) and referenced to the volumetric flow rate of the waste stream treated. When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan,2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 1999). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (10 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$3 to \$28 per scfm
 Typical value is \$11 per scfm

O&M Costs:

Range from \$4 to \$119 per scfm
 Typical value is \$42 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for Impingement Plate

AT-A-GLANCE TABLE FOR POINT SOURCES

Scrubbers (EPA, 1996). O&M costs were calculated for two model plants with flow rates of 2,000 and 150,000 acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. The model plants were assumed to have a dust loading of 3.0 grains per cubic feet. The operating time was assumed to be 8760 hours per year. An inlet water flow rate for the scrubber was assumed to be 9.4 lbs/min. The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.067	\$/kW-hr
Process water price	0.20	\$/1000 gal
Dust disposal	25	\$/ton disposed
Wastewater treatment	3.8	\$/ thousand gal treated

Note: All costs are in 1995 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$76 to \$2,100 per ton PM₁₀ removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$751 per ton PM₁₀ reduced. (1995\$)

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

Thermal dryers are used at the end of the series of cleaning operations to remove moisture from coal, thereby reducing freezing problems and weight, and increasing the heating value. The major portion of water is removed by the use of screens, thickeners, and cyclones. The coal is then dried in a thermal dryer. Particulate emissions result from the entrainment of fine coal particles during the thermal drying process (EPA, 1995). Pneumatic coal-cleaning equipment classifies bituminous coal by size or separates bituminous coal from refuse by application of air streams. Fugitive PM emissions result when haul trucks or other vehicles travel on unpaved roads or surfaces.

The costs do not include costs for post-treatment or disposal of used solvent or waste. Actual costs can be substantially higher than in the ranges shown for applications which require expensive materials, solvents, or treatment methods (EPA, 1999). As a rule, smaller units controlling a low concentration waste stream will be much more expensive (per unit volumetric flow rate) than a large unit cleaning a high pollutant load flow.

By product coke production is used to manufacture metallurgical coke by heating high-grade bituminous coal (low sulfur and low ash) in an enclosed oven chamber without oxygen. The resulting solid material consists of elemental carbon and any minerals (ash) that were present in the coal blend that did not volatilize during the process. Sources of air emissions consist of coke oven doors, coke oven lids and off-takes, coke oven charging, coke oven pushing, coke oven underfire stack, coke quenching, battery venting, and coke by-product-recovery plants.

A venturi scrubber accelerates the waste gas stream to improve gas-liquid contact. In a venturi scrubber, a "throat" section is built into the duct that forces the gas stream to accelerate (EPA, 1999). As the gas enters the venturi throat, both gas velocity and turbulence increase.

After the throat section, the mixture decelerates, and further impacts occur causing the droplets to agglomerate. Once the particles have been captured by the liquid, the wetted PM and excess liquid are separated from the gas stream through entrainment. This section usually consists of a cyclonic separator and/or a mist eliminator (EPA, 1998; Corbitt, 1990).

AT-A-GLANCE TABLE FOR POINT SOURCES

For PM applications, wet scrubbers generate waste, either a slurry or wet sludge. This creates the need for both wastewater treatment and solid waste disposal. Initially, the slurry is treated to separate the solid waste from the water (EPA, 1999). The treated water can then be reused or discharged. Once the water is removed, the remaining waste will be in the form of a solid or sludge. If the solid waste is inert and nontoxic, it can generally be land filled. Hazardous wastes will have more stringent procedures for disposal. In some cases, the solid waste may have value and can be sold or recycled (EPA, 1998).

References:

Corbitt, 1990: "Standard Handbook of Environmental Engineering," edited by Robert A. Corbitt, McGraw-Hill, New York, NY, 1990.

EPA, 1995: U.S. Environmental Protection Agency, "Compilation of Air Pollutant Emission Factors," AP-42, Volume I, Fifth Edition, Research Triangle Park, NC, January 1995.

EPA, 1996: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, EPA 453/B-96-001, Research Triangle Park, NC February.

EPA, 1998: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

EPA, 1999: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Venturi Scrubber," July 1999.

Heumann, 1997: W. L. Heumann, "Industrial Air Pollution Control Systems," McGraw Hill Publishers, Inc., Washington, D.C., 1997.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

STAPPA/ALAPCO, 1996: State and Territorial Air Pollution Program Administrators and Association of Local Air Pollution Control Officials, "Controlling Particulate Matter Under the Clean Air Act: A Menu of Options," July 1996.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Mineral Products - Coal Cleaning

Control Measure Name: Increased Monitoring Frequency (IMF) of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P3219

POD: 219

Application: This measure is to conduct improved monitoring for PM_{2.5} emissions at stationary sources. Improved monitoring in this case means increasing the monitoring frequency of electrostatic precipitators, scrubbers, and fabric filters from once per day to four times per hour, with no change in monitoring technique.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (Barr and Schaffner) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

305010** Mineral Products, Coal Mining, Cleaning, and Material Handling

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 6.5% for both PM₁₀ and PM_{2.5}

Equipment Life: Not applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs included the incremental record keeping and reporting associated with the increased monitoring frequency. Labor rates for 2003 were made that were obtained from the Bureau of Labor Statistics (labor rates include 140 percent overhead). The incremental costs included a one-time cost for development of the improved monitoring and recurring annual burden costs for incremental record keeping, reporting, and certification activities.

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$620 per ton PM reduced (2003\$).

Comments:

Status:

Last Reviewed: 2004

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM_{2.5} Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 2003.

BLS, 2003: Bureau of Labor Statistics, "Employer Costs for Employee Compensation – June 2003," Table 12, page 16, 2003.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Mineral Products - Coal Cleaning

Control Measure Name: CEM Upgrade and Increased Monitoring Frequency of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P4219

POD: 219

Application: This measure examines the impacts of improving the PM monitoring technique at units currently using an ESP, scrubber, or fabric filter. In this improved technique scenario, the monitoring technique is upgraded to a PM continuous emission monitor. This improved monitoring technique also results in an increase to the monitoring frequency because a PM CEMS can make a measurement every 7.5 minutes. The monitoring frequency increases from once per day to eight times per hour.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (see References) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

305010** Mineral Products, Coal Mining, Cleaning, and Material Handling

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 7.7% for both PM10 and PM2.5

Equipment Life: Unknown

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The total capital and annual operating costs for implementing an improved monitoring technique are calculated based on data from the EPA CEMS Cost Model and the PM CEMS Knowledge document. Labor rates in the EPA CEMS Cost Model are scaled to reflect 2003 labor rates (including 140 percent overhead) provided by the Bureau of Labor Statistics.

The cost effectiveness at a percent excess emission rate of 0.46 percent is \$5,200 per ton of PM2.5. This is based on a \$34 million capital investment cost, and a \$14 million total annualized cost when applied to 128 facilities.

Note: All costs are in 2003 dollars.

AT-A-GLANCE TABLE FOR POINT SOURCES

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$5,200 per ton PM reduced (2003\$).

Comments:

Status:

Last Reviewed: 2004

Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM_{2.5} Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 8, 2003.

EPA CEMS Cost Model, Version 3.0, U.S. Environmental Protection Agency.

EPA, 2000: U.S. Environmental Protection Agency, "Current Knowledge of Particulate Matter (PM) Continuous Emissions Monitoring," Chapter 9, PM CEMS Cost, September 8, 2000.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Mineral Products - Other

Control Measure Name: Fabric Filter (Pulse Jet Type)

Rule Name: Not Applicable

Pechan Measure Code: P2211

POD: 221

Application: This control is the addition of a pulse-jet cleaned fabric filter to reduce PM emissions from waste streams. In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Particulate-laden gas flows into the filter bag from the outside to the inside. The particles collected on the outside drop into a hopper below the fabric filter. During pulse-jet cleaning, a short burst of high pressure air is injected into the bags, dislodging the dust cake.

This control applies to miscellaneous mineral production operations including (but not limited to) brick manufacture, calcium carbide operations, clay and fly ash sintering, concrete batching, gypsum manufacturing, lime production, phosphate rock operations, sand production, fiberglass manufacturing and glass manufacturing operations. Materials handling operations including crushing, grinding, and screening, can produce significant PM emissions.

Affected SCC:

30500301 Mineral Products, Brick Manufacture, Raw Material Drying
30500302 Mineral Products, Brick Manufacture, Raw Material Grinding & Screening
30500303 Brick Manufacture, Storage of Raw Materials
30500305 Brick Manufacture, Raw Material Handling and Transferring
30500308 Brick Manufacture, Screening
30500309 Brick Manufacture, Blending and Mixing
30500310 Brick Manufacture, Curing and Firing: Sawdust Fired Tunnel Kilns
30500311 Mineral Products, Brick Manufacture, Curing and Firing: Gas-fired Tunnel Kilns
30500313 Mineral Products, Brick Manufacture, Curing and Firing: Coal-fired Tunnel Kilns
30500316 Brick Manufacture, Curing and Firing: Coal-fired Periodic Kilns
30500331 Brick Manufacture, Curing and Firing: Dual Fuel Fired Tunnel Kiln
30500398 Mineral Products, Brick Manufacture, Other Not Classified
30500399 Brick Manufacture, Other Not Classified
30500401 Calcium Carbide, Electric Furnace: Hoods and Main Stack
30500402 Mineral Products, Calcium Carbide, Coke Dryer
30500404 Calcium Carbide, Tap Fume Vents
30500406 Mineral Products, Calcium Carbide, Circular Charging: Conveyor
30500499 Mineral Products, Calcium Carbide, Other Not Classified
30500501 Castable Refractory, Fire Clay: Rotary Dryer
30500502 Castable Refractory, Raw Material Crushing/Processing
30500598 Castable Refractory, Other Not Classified
30500599 Castable Refractory, Other Not Classified
30500801 Ceramic Clay/Tile Manufacture, Drying ** (use SCC 3-05-008-13)
30500802 Mineral Products, Ceramic Clay/Tile, Comminution-Crushing, Grinding & Milling
30500803 Ceramic Clay/Tile Manufacture, Raw Material Storage
30500805 Ceramic Clay/Tile Manufacture, Granulation-Mixing of Ceramic Powder & Binder Sol'n
30500899 Mineral Products, Ceramic Clay/Tile Manufacture, Other Not Classified
30500901 Clay and Fly Ash Sintering, Fly Ash Sintering
30500902 Clay and Fly Ash Sintering, Clay/Coke Sintering
30500903 Clay and Fly Ash Sintering, Natural Clay/Shale Sintering

AT-A-GLANCE TABLE FOR POINT SOURCES

30500904 Clay and Fly Ash Sintering, Raw Clay/Shale Crushing/Screening
30500905 Clay and Fly Ash Sintering, Raw Clay/Shale Transfer/Conveying
30500908 Clay and Fly Ash Sintering, Sintered Clay/Shale Product Crushing/Screening
30500909 Clay and Fly Ash Sintering, Expanded Shale Clinker Cooling
30500910 Clay and Fly Ash Sintering, Expanded Shale Storage
30500915 Clay and Fly Ash Sintering, Rotary Kiln
30500999 Mineral Products, Clay and Fly Ash Sintering, Other Not Classified
30501101 Mineral Products, Concrete Batching, General (Non-fugitive)
30501106 Concrete Batching, Transfer: Sand/Aggregate to Elevated Bins
30501107 Concrete Batching, Cement Unloading: Storage Bins
30501108 Concrete Batching, Weight Hopper Loading of Cement/Sand/Aggregate
30501109 Mineral Products, Concrete Batching, Mixer Loading of Cement/Sand/Aggregate
30501110 Concrete Batching, Loading of Transit Mix Truck
30501111 Concrete Batching, Loading of Dry-batch Truck
30501112 Mineral Products, Concrete Batching, Mixing: Wet
30501113 Concrete Batching, Mixing: Dry
30501114 Concrete Batching, Transferring: Conveyors/Elevators
30501115 Concrete Batching, Storage: Bins/Hoppers
30501199 Mineral Products, Concrete Batching, Other Not Classified
30501201 Fiberglass Manufacturing, Regenerative Furnace (Wool-type Fiber)
30501203 Fiberglass Manufacturing, Electric Furnace (Wool-type Fiber)
30501204 Fiberglass Manufacturing, Forming: Rotary Spun (Wool-type Fiber)
30501205 Fiberglass Manufacturing, Curing Oven: Rotary Spun (Wool-type Fiber)
30501206 Fiberglass Manufacturing, Cooling (Wool-type Fiber)
30501207 Fiberglass Manufacturing, Unit Melter Furnace (Wool-type Fiber)
30501208 Fiberglass Manufacturing, Forming: Flame Attenuation (Wool-type Fiber)
30501209 Fiberglass Manufacturing, Curing: Flame Attenuation (Wool-type Fiber)
30501211 Fiberglass Manufacturing, Regenerative Furnace (Textile-type Fiber)
30501212 Fiberglass Manufacturing, Recuperative Furnace (Textile-type Fiber)
30501213 Fiberglass Manufacturing, Unit Melter Furnace (Textile-type Fiber)
30501214 Fiberglass Manufacturing, Forming Process (Textile-type Fiber)
30501215 Fiberglass Manufacturing, Curing Oven (Textile-type Fiber)
30501221 Fiberglass Manufacturing, Raw Material: Unloading/Conveying
30501223 Fiberglass Manufacturing, Raw Material: Mixing/Weighing
30501299 Mineral Products, Fiberglass Manufacturing, Other Not Classified
30501401 Glass Manufacture, Furnace/General**
30501402 Mineral Products, Glass Manufacture, Container Glass: Melting Furnace
30501403 Mineral Products, Glass Manufacture, Flat Glass: Melting Furnace
30501404 Glass Manufacture, Pressed and Blown Glass: Melting Furnace
30501406 Mineral Products, Glass Manufacture, Container Glass: Forming/Finishing
30501407 Glass Manufacture, Flat Glass: Forming/Finishing
30501408 Glass Manufacture, Pressed and Blown Glass: Forming/Finishing
30501410 Glass Manufacture, Raw Material Handling (All Types of Glass)
30501411 Glass Manufacture, General **
30501413 Mineral Products, Glass Manufacture, Cullet: Crushing/Grinding
30501415 Mineral Products, Glass Manufacture, Glass Etching with Hydrofluoric Acid Solution
30501416 Glass Manufacture, Glass Manufacturing
30501499 Glass Manufacture, See Comment **
30501501 Mineral Products, Gypsum Manufacture, Rotary Ore Dryer
30501502 Mineral Products, Gypsum Manufacture, Primary Grinder/Roller Mills
30501503 Gypsum Manufacture, Not Classified **
30501504 Mineral Products, Gypsum Manufacture, Conveying

AT-A-GLANCE TABLE FOR POINT SOURCES

30501505 Gypsum Manufacture, Primary Crushing: Gypsum Ore
30501506 Gypsum Manufacture, Secondary Crushing: Gypsum Ore
30501507 Gypsum Manufacture, Screening: Gypsum Ore
30501508 Mineral Products, Gypsum Manufacture, Stockpile: Gypsum Ore
30501509 Mineral Products, Gypsum Manufacture, Storage Bins: Gypsum Ore
30501511 Gypsum Manufacture, Continuous Kettle: Calciner
30501512 Gypsum Manufacture, Flash Calciner
30501513 Gypsum Manufacture, Impact Mill
30501514 Gypsum Manufacture, Storage Bins: Stucco
30501515 Gypsum Manufacture, Tube/Ball Mills
30501516 Gypsum Manufacture, Mixers
30501518 Mineral Products, Gypsum Manufacture, Mixers/Conveyors
30501519 Gypsum Manufacture, Forming Line
30501520 Mineral Products, Gypsum Manufacture, Drying Kiln
30501521 Mineral Products, Gypsum Manufacture, End Sawing (8 Ft.)
30501522 Mineral Products, Gypsum Manufacture, End Sawing (12 Ft.)
30501601 Lime Manufacture, Primary Crushing
30501602 Lime Manufacture, Secondary Crushing/Screening
30501603 Mineral Products, Lime Manufacture, Calcining: Vertical Kiln
30501604 Mineral Products, Lime, Calcining-Rotary Kiln (See SCCs 305016-18,-19,-20,-21)
30501605 Mineral Products, Lime Manufacture, Calcining: Gas-fired Calcimatic Kiln
30501606 Lime Manufacture, Fluidized Bed Kiln
30501607 Lime Manufacture, Raw Material Transfer and Conveying
30501608 Lime Manufacture, Raw Material Unloading
30501609 Lime Manufacture, Hydrator: Atmospheric
30501610 Lime Manufacture, Raw Material Storage Piles
30501611 Lime Manufacture, Product Cooler
30501612 Lime Manufacture, Pressure Hydrator
30501613 Mineral Products, Lime Manufacture, Lime Silos
30501614 Lime Manufacture, Packing/Shipping
30501615 Lime Manufacture, Product Transfer and Conveying
30501616 Lime Manufacture, Primary Screening
30501617 Lime Manufacture, Multiple Hearth Calciner
30501619 Lime Manufacture, Calcining: Gas-fired Rotary Kiln
30501620 Lime Manufacture, Calcining: Coal- and Gas-fired Rotary Kiln
30501626 Lime Manufacture, Product Loading, Enclosed Truck
30501640 Lime Manufacture, Vehicle Traffic
30501699 Lime Manufacture, See Comment **
30501701 Mineral Wool, Cupola
30501703 Mineral Wool, Blow Chamber
30501704 Mineral Wool, Curing Oven
30501705 Mineral Wool, Cooler
30501799 Mineral Wool, Other Not Classified
30501801 Perlite Manufacturing, Vertical Furnace
30501899 Perlite Manufacturing, Other Not Classified
30501901 Phosphate Rock, Drying
30501902 Phosphate Rock, Grinding
30501903 Phosphate Rock, Transfer/Storage
30501905 Mineral Products, Phosphate Rock, Calcining
30501906 Phosphate Rock, Rotary Dryer
30501907 Phosphate Rock, Ball Mill
30501999 Phosphate Rock, Other Not Classified

AT-A-GLANCE TABLE FOR POINT SOURCES

30502101 Salt Mining, General
30502201 Potash Production, Mine: Grinding/Drying
30502299 Potash Production, Other Not Classified
30502401 Magnesium Carbonate, Mine/Process
30502501 Construction Sand and Gravel, Total Plant: General **
30502502 Construction Sand and Gravel, Aggregate Storage
30502503 Construction Sand and Gravel, Material Transfer and Conveying
30502504 Construction Sand and Gravel, Hauling
30502505 Construction Sand and Gravel, Pile Forming: Stacker
30502506 Construction Sand and Gravel, Bulk Loading
30502507 Construction Sand and Gravel, Storage Piles
30502508 Construction Sand & Gravel, Dryer (See 305027-20 thru -24 for Industrial Sand Dryers)
30502509 Construction Sand and Gravel, Cooler ** (See 3-05-027-30 for Industrial Sand Coolers)
30502510 Mineral Products, Construction Sand and Gravel, Crushing
30502511 Construction Sand and Gravel, Screening
30502599 Construction Sand and Gravel, Not Classified **
30502601 Diatomaceous Earth, Handling
30502699 Diatomaceous Earth, Other Not Classified
30502701 Industrial Sand and Gravel, Primary Crushing of Raw Material
30502705 Industrial Sand and Gravel, Secondary Crushing
30502709 Industrial Sand and Gravel, Grinding: Size Reduction to 50 Microns or Smaller
30502713 Industrial Sand and Gravel, Screening: Size Classification
30502760 Industrial Sand and Gravel, Sand Handling, Transfer, and Storage
30503099 Ceramic Electric Parts, Other Not Classified
30503301 Vermiculite, General
30504001 Mining and Quarrying of Nonmetallic Minerals, Open Pit Blasting
30504002 Mining and Quarrying of Nonmetallic Minerals, Open Pit Drilling
30504003 Mining and Quarrying of Nonmetallic Minerals, Open Pit Cobbing
30504010 Mining and Quarrying of Nonmetallic Minerals, Underground Ventilation
30504020 Mining and Quarrying of Nonmetallic Minerals, Loading
30504021 Mineral Products, Mining and Quarrying of Nonmetallic Minerals, Convey/Haul Material
30504022 Mining and Quarrying of Nonmetallic Minerals, Convey/Haul Waste
30504023 Mining and Quarrying of Nonmetallic Minerals, Unloading
30504024 Mining and Quarrying of Nonmetallic Minerals, Overburden Stripping
30504025 Mining and Quarrying of Nonmetallic Minerals, Stockpiling
30504030 Mineral Products, Mining and Quarrying of Nonmetallic Minerals, Primary Crusher
30504031 Mineral Products, Mining and Quarrying of Nonmetallic Minerals, Secondary Crusher
30504033 Mining and Quarrying of Nonmetallic Minerals, Ore Dryer
30504034 Mining and Quarrying of Nonmetallic Minerals, Screening
30504036 Mining and Quarrying of Nonmetallic Minerals, Tailing Piles
30504099 Mining and Quarrying of Nonmetallic Minerals, Other Not Classified
30504140 Clay processing: Kaolin, Calcining, rotary calciner
30510001 Bulk Materials Elevators, Unloading
30510002 Bulk Materials Elevators, Loading
30510101 Bulk Materials Conveyors, Ammonium Sulfate
30510103 Bulk Materials Conveyors, Coal
30510104 Bulk Materials Conveyors, Coke
30510105 Bulk Materials Conveyors, Limestone
30510197 Bulk Materials Conveyors, Fertilizer: Specify in Comments
30510198 Bulk Materials Conveyors, Mineral: Specify in Comments
30510199 Bulk Materials Conveyors, Other Not Classified
30510202 Mineral Products, Bulk Materials Storage Bins, Cement

AT-A-GLANCE TABLE FOR POINT SOURCES

30510203 Bulk Materials Storage Bins, Coal
 30510204 Bulk Materials Storage Bins, Coke
 30510205 Bulk Materials Storage Bins, Limestone
 30510298 Mineral Products, Bulk Materials Storage Bins, Mineral: Specify in Comments
 30510299 Bulk Materials Storage Bins, Other Not Classified
 30510303 Bulk Materials Open Stockpiles, Coal
 30510304 Bulk Materials Open Stockpiles, Coke
 30510397 Bulk Materials Open Stockpiles, Fertilizer: Specify in Comments
 30510398 Bulk Materials Open Stockpiles, Mineral: Specify in Comments
 30510399 Bulk Materials Open Stockpiles, Other Not Classified
 30510402 Bulk Materials Unloading Operation, Cement
 30510403 Mineral Products, Bulk Materials Unloading Operation, Coal
 30510404 Bulk Materials Unloading Operation, Coke
 30510405 Bulk Materials Unloading Operation, Limestone
 30510406 Bulk Materials Unloading Operation, Phosphate Rock
 30510407 Bulk Materials Unloading Operation, Scrap Metal
 30510497 Bulk Materials Unloading Operation, Fertilizer: Specify in Comments
 30510498 Bulk Materials Unloading Operation, Mineral: Specify in Comments
 30510499 Bulk Materials Unloading Operation, Other Not Classified
 30510503 Bulk Materials Loading Operation, Coal
 30510505 Bulk Materials Loading Operation, Limestone
 30510507 Bulk Materials Loading Operation, Scrap Metal
 30510596 Bulk Materials Loading Operation, Chemical: Specify in Comments
 30510597 Bulk Materials Loading Operation, Fertilizer: Specify in Comments
 30510598 Bulk Materials Loading Operation, Mineral: Specify in Comments
 30510599 Bulk Materials Loading Operation, Other Not Classified
 30515001 Calcining, Raw Material Handling
 30515002 Calcining, General
 30515004 Calcining, Finished Product Handling
 30531008 Coal Mining, Cleaning, and Material Handling (See 305010), Unloading
 30531009 Coal Mining, Cleaning, and Material Handling (See 305010), Raw Coal Storage
 30531010 Coal Mining, Cleaning, and Material Handling (See 305010), Crushing
 30531011 Coal Mining, Cleaning, and Material Handling (See 305010), Coal Transfer
 30531012 Coal Mining, Cleaning, and Material Handling (See 305010), Screening
 30531014 Coal Mining, Cleaning, and Material Handling (See 305010), Cleaned Coal Storage
 30531090 Coal Mining, Cleaning, and Material Handling (See 305010), Haul Roads: General
 30531099 Coal Mining, Cleaning, and Material Handling (See 305010), Other Not Classified
 30532006 Stone Quarrying-Processing (See 305020), Misc. Operations
 30532008 Stone Quarrying - Processing (See also 305020 for diff. units), Cut Stone: General
 30588801 Fugitive Emissions, Specify in Comments Field
 30588802 Fugitive Emissions, Specify in Comments Field
 30588803 Fugitive Emissions, Specify in Comments Field
 30588804 Fugitive Emissions, Specify in Comments Field
 30588805 Fugitive Emissions, Specify in Comments Field
 30590001 Fuel Fired Equipment, Distillate Oil (No. 2): Process Heaters
 30590003 Fuel Fired Equipment, Natural Gas: Process Heaters
 30590023 Fuel Fired Equipment, Natural Gas: Flares
 30599999 Mineral Products, Other Not Defined, Specify in Comments Field

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

AT-A-GLANCE TABLE FOR POINT SOURCES

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 99% from uncontrolled for both PM10 and PM2.5

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs for pulse-jet cleaned systems are generated using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan, 2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 2000). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$6 to \$26 per scfm
Typical value is \$13 per scfm

O&M Costs:

Range from \$5 to \$24 per scfm
Typical value is \$11 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). O&M costs were calculated for three model plants with flow rates of 25, 75 and 150 thousand acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust loading of 4.0 grains per cubic feet. The operating time was assumed to be 8760 hours per year. An average bag cost was estimated using the costs for standard bag types. Capital recovery for the periodic replacement of bags was included in the O&M cost of the bags using a bag life of 2 years (EPA, 1998a). The following assumptions apply to the cost of utilities and disposal:

AT-A-GLANCE TABLE FOR POINT SOURCES

Electricity price	0.0671	\$/kW-hr
Compressed air	0.25	\$/1000 scf
Dust disposal	25	\$/ton disposed

Note: All costs are in 1998 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$42 to \$266 per ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$117 per ton PM10 reduced. (1998\$)

Comments:

Status: Demonstrated	Last Reviewed: 2001
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Additional Information:

Drying, the heating of minerals or mineral products to remove water, and calcination, heating to higher temperatures to remove chemically bound water and other compounds, are normally performed in dedicated, closed units. Emissions from these units will be through process vents, to which PM controls can be applied relatively simply. Fugitive dust emissions may come from paved and unpaved roads in plants and from raw material and product loading, unloading, and storage (STAPPA/ALAPCO, 1996).

The cost estimates assume a conventional design under typical operating conditions and do not include auxiliary equipment such as fans and ductwork. The costs for pulse-jet cleaned systems are generated using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a).

Costs are primarily based on volumetric flow rate and the amount of PM in the waste stream. In general, a small unit controlling a low pollutant levels will not be as cost effective as a large unit controlling a high pollutant levels. (EPA, 2000)

Pollutants requiring a high level of control or the fabric filters to be constructed of special materials will increase the costs of the system (EPA, 1998a). The additional costs for controlling complex waste streams are not included in the estimates. For these systems, the capital cost could increase by as much as 75% and the operational and maintenance (O&M) cost could increase by as much as 20% (EPA, 2000).

In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Fabric filters may be in the form of sheets, cartridges, or bags, with many individual filter units together in a group. Bags are the most common type of filter. The dust cake that forms on the filter from the collected PM can significantly increase collection efficiency. (EPA, 2000)

Pulse-jet cleaning of fabric filters is a relatively new type of fabric filter, as they have only been used for the past 30 years. This cleaning mechanism has grown in popularity because it can treat high dust loadings, operate at constant pressure drop, and occupy less space than other types of fabric filters (EPA, 2000). Particulate-laden gas flows into the bag. The gas flows from the outside to the inside of the bags, and then out the gas exhaust. The particles collected on the outside drop into a hopper below the fabric filter (EPA, 1998b).

During pulse-jet cleaning, a short burst of high pressure air is injected into the bags (EPA, 1998b). The pulse is blown through a venturi nozzle at the top of the bags and establishes a shock wave that continues onto the bottom of the bag. The wave flexes the fabric dislodging the dust cake.

AT-A-GLANCE TABLE FOR POINT SOURCES

There are several unique attributes of pulse-jet cleaning. The cleaning pulse is very brief allowing the flow of dusty gas to continue during cleaning. The bags not being cleaned continue to filter, taking on extra duty from the bags being cleaned (EPA, 2000). Pulse-jet cleaning is more intense and occurs with greater frequency than the other fabric filter cleaning methods. The cleaning dislodges nearly all of the dust cake each time the bag is pulsed. Pulse-jet filters, as a result, do not rely on a dust cake to provide filtration. Felted (non-woven) fabrics are used in these types of filters because they do not require a dust cake. Also it has been found that woven fabrics used with pulse-jet cleaning leak dust after they are cleaned (EPA, 1998b).

Since bags cleaned by the pulse-jet method do not need to be isolated for cleaning, pulsejet cleaned fabric filters do not need extra compartments to maintain adequate filtration during cleaning. Also, because of the intense and frequent nature of the cleaning, they can treat higher gas flow rates with higher dust loadings. Consequently, fabric filters cleaned by the pulse-jet method can be smaller than other filters in the treatment of the same amount of gas and dust, making higher gas-to-cloth ratios achievable (EPA, 1998b).

Fabric filters are useful for collecting particles with resistivities either too low or too high for collection with electrostatic precipitators. Fabric filters are useful in controlling particulate matter less than or equal to 10 micrometers (μm) in diameter (PM10) and particulate matter less than or equal to 2.5 μm in diameter (PM2.5). Fabric filters may be good candidates for collecting fly ash from low-sulfur coals or containing high unburned carbon levels and are relatively difficult to collect with electrostatic precipitators. (EPA, 2000)

References:

EPA, 1998a: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, Chapter 5, EPA 453/B-96-001, Research Triangle Park, NC. December 1998.

EPA, 1998b: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

EPA, 2000: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Fabric Filter - Pulse-Jet Cleaned Type," April 2000.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

STAPPA/ALAPCO, 1996: State and Territorial Air Pollution Program Administrators - Association of Local Air Pollution Control Officials, Controlling Particulate Matter Under the Clean Air Act: A Menu of Options, Washington, DC, July 1996.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Mineral Products - Other

Control Measure Name: Fabric Filter (Mech. Shaker Type)

Rule Name: Not Applicable

Pechan Measure Code: P2212

POD: 221

Application: This control is the addition of a mechanical shaker type fabric filter to reduce PM emissions. In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. The gas stream is drawn from beneath a cell plate in the floor and into the filter bags. The gas proceeds from the inside to the outside of the filter bags. The particles collect on the inside of the bags, forming a filter cake. In mechanical shaking units, the tops of bags are attached to a shaker bar, moved briskly to clean the bags.

This control applies to miscellaneous mineral production operations including (but not limited to) brick manufacture, calcium carbide operations, clay and fly ash sintering, concrete batching, gypsum manufacturing, lime production, phosphate rock operations, sand production, fiberglass manufacturing and glass manufacturing operations.

Affected SCC:

30500301 Mineral Products, Brick Manufacture, Raw Material Drying
30500302 Mineral Products, Brick Manufacture, Raw Material Grinding & Screening
30500303 Brick Manufacture, Storage of Raw Materials
30500305 Brick Manufacture, Raw Material Handling and Transferring
30500308 Brick Manufacture, Screening
30500309 Brick Manufacture, Blending and Mixing
30500310 Brick Manufacture, Curing and Firing: Sawdust Fired Tunnel Kilns
30500311 Mineral Products, Brick Manufacture, Curing and Firing: Gas-fired Tunnel Kilns
30500313 Mineral Products, Brick Manufacture, Curing and Firing: Coal-fired Tunnel Kilns
30500316 Brick Manufacture, Curing and Firing: Coal-fired Periodic Kilns
30500331 Brick Manufacture, Curing and Firing: Dual Fuel Fired Tunnel Kiln
30500398 Mineral Products, Brick Manufacture, Other Not Classified
30500399 Brick Manufacture, Other Not Classified
30500401 Calcium Carbide, Electric Furnace: Hoods and Main Stack
30500402 Mineral Products, Calcium Carbide, Coke Dryer
30500404 Calcium Carbide, Tap Fume Vents
30500406 Mineral Products, Calcium Carbide, Circular Charging: Conveyor
30500499 Mineral Products, Calcium Carbide, Other Not Classified
30500501 Castable Refractory, Fire Clay: Rotary Dryer
30500502 Castable Refractory, Raw Material Crushing/Processing
30500598 Castable Refractory, Other Not Classified
30500599 Castable Refractory, Other Not Classified
30500801 Ceramic Clay/Tile Manufacture, Drying ** (use SCC 3-05-008-13)
30500802 Mineral Products, Ceramic Clay/Tile, Comminution-Crushing, Grinding & Milling
30500803 Ceramic Clay/Tile Manufacture, Raw Material Storage
30500805 Ceramic Clay/Tile Manufacture, Granulation-Mixing of Ceramic Powder & Binder Sol'n
30500899 Mineral Products, Ceramic Clay/Tile Manufacture, Other Not Classified
30500901 Clay and Fly Ash Sintering, Fly Ash Sintering
30500902 Clay and Fly Ash Sintering, Clay/Coke Sintering
30500903 Clay and Fly Ash Sintering, Natural Clay/Shale Sintering

AT-A-GLANCE TABLE FOR POINT SOURCES

30500904 Clay and Fly Ash Sintering, Raw Clay/Shale Crushing/Screening
30500905 Clay and Fly Ash Sintering, Raw Clay/Shale Transfer/Conveying
30500908 Clay and Fly Ash Sintering, Sintered Clay/Shale Product Crushing/Screening
30500909 Clay and Fly Ash Sintering, Expanded Shale Clinker Cooling
30500910 Clay and Fly Ash Sintering, Expanded Shale Storage
30500915 Clay and Fly Ash Sintering, Rotary Kiln
30500999 Mineral Products, Clay and Fly Ash Sintering, Other Not Classified
30501101 Mineral Products, Concrete Batching, General (Non-fugitive)
30501106 Concrete Batching, Transfer: Sand/Aggregate to Elevated Bins
30501107 Concrete Batching, Cement Unloading: Storage Bins
30501108 Concrete Batching, Weight Hopper Loading of Cement/Sand/Aggregate
30501109 Mineral Products, Concrete Batching, Mixer Loading of Cement/Sand/Aggregate
30501110 Concrete Batching, Loading of Transit Mix Truck
30501111 Concrete Batching, Loading of Dry-batch Truck
30501112 Mineral Products, Concrete Batching, Mixing: Wet
30501113 Concrete Batching, Mixing: Dry
30501114 Concrete Batching, Transferring: Conveyors/Elevators
30501115 Concrete Batching, Storage: Bins/Hoppers
30501199 Mineral Products, Concrete Batching, Other Not Classified
30501201 Fiberglass Manufacturing, Regenerative Furnace (Wool-type Fiber)
30501203 Fiberglass Manufacturing, Electric Furnace (Wool-type Fiber)
30501204 Fiberglass Manufacturing, Forming: Rotary Spun (Wool-type Fiber)
30501205 Fiberglass Manufacturing, Curing Oven: Rotary Spun (Wool-type Fiber)
30501206 Fiberglass Manufacturing, Cooling (Wool-type Fiber)
30501207 Fiberglass Manufacturing, Unit Melter Furnace (Wool-type Fiber)
30501208 Fiberglass Manufacturing, Forming: Flame Attenuation (Wool-type Fiber)
30501209 Fiberglass Manufacturing, Curing: Flame Attenuation (Wool-type Fiber)
30501211 Fiberglass Manufacturing, Regenerative Furnace (Textile-type Fiber)
30501212 Fiberglass Manufacturing, Recuperative Furnace (Textile-type Fiber)
30501213 Fiberglass Manufacturing, Unit Melter Furnace (Textile-type Fiber)
30501214 Fiberglass Manufacturing, Forming Process (Textile-type Fiber)
30501215 Fiberglass Manufacturing, Curing Oven (Textile-type Fiber)
30501221 Fiberglass Manufacturing, Raw Material: Unloading/Conveying
30501223 Fiberglass Manufacturing, Raw Material: Mixing/Weighing
30501299 Mineral Products, Fiberglass Manufacturing, Other Not Classified
30501401 Glass Manufacture, Furnace/General**
30501402 Mineral Products, Glass Manufacture, Container Glass: Melting Furnace
30501403 Mineral Products, Glass Manufacture, Flat Glass: Melting Furnace
30501404 Glass Manufacture, Pressed and Blown Glass: Melting Furnace
30501406 Mineral Products, Glass Manufacture, Container Glass: Forming/Finishing
30501407 Glass Manufacture, Flat Glass: Forming/Finishing
30501408 Glass Manufacture, Pressed and Blown Glass: Forming/Finishing
30501410 Glass Manufacture, Raw Material Handling (All Types of Glass)
30501411 Glass Manufacture, General **
30501413 Mineral Products, Glass Manufacture, Cullet: Crushing/Grinding
30501415 Mineral Products, Glass Manufacture, Glass Etching with Hydrofluoric Acid Solution
30501416 Glass Manufacture, Glass Manufacturing
30501499 Glass Manufacture, See Comment **
30501501 Mineral Products, Gypsum Manufacture, Rotary Ore Dryer
30501502 Mineral Products, Gypsum Manufacture, Primary Grinder/Roller Mills
30501503 Gypsum Manufacture, Not Classified **
30501504 Mineral Products, Gypsum Manufacture, Conveying

AT-A-GLANCE TABLE FOR POINT SOURCES

30501505 Gypsum Manufacture, Primary Crushing: Gypsum Ore
30501506 Gypsum Manufacture, Secondary Crushing: Gypsum Ore
30501507 Gypsum Manufacture, Screening: Gypsum Ore
30501508 Mineral Products, Gypsum Manufacture, Stockpile: Gypsum Ore
30501509 Mineral Products, Gypsum Manufacture, Storage Bins: Gypsum Ore
30501511 Gypsum Manufacture, Continuous Kettle: Calciner
30501512 Gypsum Manufacture, Flash Calciner
30501513 Gypsum Manufacture, Impact Mill
30501514 Gypsum Manufacture, Storage Bins: Stucco
30501515 Gypsum Manufacture, Tube/Ball Mills
30501516 Gypsum Manufacture, Mixers
30501518 Mineral Products, Gypsum Manufacture, Mixers/Conveyors
30501519 Gypsum Manufacture, Forming Line
30501520 Mineral Products, Gypsum Manufacture, Drying Kiln
30501521 Mineral Products, Gypsum Manufacture, End Sawing (8 Ft.)
30501522 Mineral Products, Gypsum Manufacture, End Sawing (12 Ft.)
30501601 Lime Manufacture, Primary Crushing
30501602 Lime Manufacture, Secondary Crushing/Screening
30501603 Mineral Products, Lime Manufacture, Calcining: Vertical Kiln
30501604 Mineral Products, Lime Manufacture, Calcining: Rotary Kiln ** (See SCC Codes 3-05-016-18,-19,-20,-21)
30501605 Mineral Products, Lime Manufacture, Calcining: Gas-fired Calcimatic Kiln
30501606 Lime Manufacture, Fluidized Bed Kiln
30501607 Lime Manufacture, Raw Material Transfer and Conveying
30501608 Lime Manufacture, Raw Material Unloading
30501609 Lime Manufacture, Hydrator: Atmospheric
30501610 Lime Manufacture, Raw Material Storage Piles
30501611 Lime Manufacture, Product Cooler
30501612 Lime Manufacture, Pressure Hydrator
30501613 Mineral Products, Lime Manufacture, Lime Silos
30501614 Lime Manufacture, Packing/Shipping
30501615 Lime Manufacture, Product Transfer and Conveying
30501616 Lime Manufacture, Primary Screening
30501617 Lime Manufacture, Multiple Hearth Calciner
30501619 Lime Manufacture, Calcining: Gas-fired Rotary Kiln
30501620 Lime Manufacture, Calcining: Coal- and Gas-fired Rotary Kiln
30501626 Lime Manufacture, Product Loading, Enclosed Truck
30501640 Lime Manufacture, Vehicle Traffic
30501699 Lime Manufacture, See Comment **
30501701 Mineral Wool, Cupola
30501703 Mineral Wool, Blow Chamber
30501704 Mineral Wool, Curing Oven
30501705 Mineral Wool, Cooler
30501799 Mineral Wool, Other Not Classified
30501801 Perlite Manufacturing, Vertical Furnace
30501899 Perlite Manufacturing, Other Not Classified
30501901 Phosphate Rock, Drying
30501902 Phosphate Rock, Grinding
30501903 Phosphate Rock, Transfer/Storage
30501905 Mineral Products, Phosphate Rock, Calcining
30501906 Phosphate Rock, Rotary Dryer
30501907 Phosphate Rock, Ball Mill

AT-A-GLANCE TABLE FOR POINT SOURCES

30501999 Phosphate Rock, Other Not Classified
30502101 Salt Mining, General
30502201 Potash Production, Mine: Grinding/Drying
30502299 Potash Production, Other Not Classified
30502401 Magnesium Carbonate, Mine/Process
30502501 Construction Sand and Gravel, Total Plant: General **
30502502 Construction Sand and Gravel, Aggregate Storage
30502503 Construction Sand and Gravel, Material Transfer and Conveying
30502504 Construction Sand and Gravel, Hauling
30502505 Construction Sand and Gravel, Pile Forming: Stacker
30502506 Construction Sand and Gravel, Bulk Loading
30502507 Construction Sand and Gravel, Storage Piles
30502508 Construction Sand & Gravel, Dryer (See 305027-20 thru -24 for Industrial Sand Dryers)
30502509 Construction Sand and Gravel, Cooler ** (See 3-05-027-30 for Industrial Sand Coolers)
30502510 Mineral Products, Construction Sand and Gravel, Crushing
30502511 Construction Sand and Gravel, Screening
30502599 Construction Sand and Gravel, Not Classified **
30502601 Diatomaceous Earth, Handling
30502699 Diatomaceous Earth, Other Not Classified
30502701 Industrial Sand and Gravel, Primary Crushing of Raw Material
30502705 Industrial Sand and Gravel, Secondary Crushing
30502709 Industrial Sand and Gravel, Grinding: Size Reduction to 50 Microns or Smaller
30502713 Industrial Sand and Gravel, Screening: Size Classification
30502760 Industrial Sand and Gravel, Sand Handling, Transfer, and Storage
30503099 Ceramic Electric Parts, Other Not Classified
30503301 Vermiculite, General
30504001 Mining and Quarrying of Nonmetallic Minerals, Open Pit Blasting
30504002 Mining and Quarrying of Nonmetallic Minerals, Open Pit Drilling
30504003 Mining and Quarrying of Nonmetallic Minerals, Open Pit Cobbing
30504010 Mining and Quarrying of Nonmetallic Minerals, Underground Ventilation
30504020 Mining and Quarrying of Nonmetallic Minerals, Loading
30504021 Mineral Products, Mining and Quarrying of Nonmetallic Minerals, Convey/Haul Material
30504022 Mining and Quarrying of Nonmetallic Minerals, Convey/Haul Waste
30504023 Mining and Quarrying of Nonmetallic Minerals, Unloading
30504024 Mining and Quarrying of Nonmetallic Minerals, Overburden Stripping
30504025 Mining and Quarrying of Nonmetallic Minerals, Stockpiling
30504030 Mineral Products, Mining and Quarrying of Nonmetallic Minerals, Primary Crusher
30504031 Mineral Products, Mining and Quarrying of Nonmetallic Minerals, Secondary Crusher
30504033 Mining and Quarrying of Nonmetallic Minerals, Ore Dryer
30504034 Mining and Quarrying of Nonmetallic Minerals, Screening
30504036 Mining and Quarrying of Nonmetallic Minerals, Tailing Piles
30504099 Mining and Quarrying of Nonmetallic Minerals, Other Not Classified
30504140 Clay processing: Kaolin, Calcining, rotary calciner
30510001 Bulk Materials Elevators, Unloading
30510002 Bulk Materials Elevators, Loading
30510101 Bulk Materials Conveyors, Ammonium Sulfate
30510103 Bulk Materials Conveyors, Coal
30510104 Bulk Materials Conveyors, Coke
30510105 Bulk Materials Conveyors, Limestone
30510197 Bulk Materials Conveyors, Fertilizer: Specify in Comments
30510198 Bulk Materials Conveyors, Mineral: Specify in Comments
30510199 Bulk Materials Conveyors, Other Not Classified

AT-A-GLANCE TABLE FOR POINT SOURCES

30510202 Mineral Products, Bulk Materials Storage Bins, Cement
30510203 Bulk Materials Storage Bins, Coal
30510204 Bulk Materials Storage Bins, Coke
30510205 Bulk Materials Storage Bins, Limestone
30510298 Mineral Products, Bulk Materials Storage Bins, Mineral: Specify in Comments
30510299 Bulk Materials Storage Bins, Other Not Classified
30510303 Bulk Materials Open Stockpiles, Coal
30510304 Bulk Materials Open Stockpiles, Coke
30510397 Bulk Materials Open Stockpiles, Fertilizer: Specify in Comments
30510398 Bulk Materials Open Stockpiles, Mineral: Specify in Comments
30510399 Bulk Materials Open Stockpiles, Other Not Classified
30510402 Bulk Materials Unloading Operation, Cement
30510403 Mineral Products, Bulk Materials Unloading Operation, Coal
30510404 Bulk Materials Unloading Operation, Coke
30510405 Bulk Materials Unloading Operation, Limestone
30510406 Bulk Materials Unloading Operation, Phosphate Rock
30510407 Bulk Materials Unloading Operation, Scrap Metal
30510497 Bulk Materials Unloading Operation, Fertilizer: Specify in Comments
30510498 Bulk Materials Unloading Operation, Mineral: Specify in Comments
30510499 Bulk Materials Unloading Operation, Other Not Classified
30510503 Bulk Materials Loading Operation, Coal
30510505 Bulk Materials Loading Operation, Limestone
30510507 Bulk Materials Loading Operation, Scrap Metal
30510596 Bulk Materials Loading Operation, Chemical: Specify in Comments
30510597 Bulk Materials Loading Operation, Fertilizer: Specify in Comments
30510598 Bulk Materials Loading Operation, Mineral: Specify in Comments
30510599 Bulk Materials Loading Operation, Other Not Classified
30515001 Calcining, Raw Material Handling
30515002 Calcining, General
30515004 Calcining, Finished Product Handling
30531008 Coal Mining, Cleaning, and Material Handling (See 305010), Unloading
30531009 Coal Mining, Cleaning, and Material Handling (See 305010), Raw Coal Storage
30531010 Coal Mining, Cleaning, and Material Handling (See 305010), Crushing
30531011 Coal Mining, Cleaning, and Material Handling (See 305010), Coal Transfer
30531012 Coal Mining, Cleaning, and Material Handling (See 305010), Screening
30531014 Coal Mining, Cleaning, and Material Handling (See 305010), Cleaned Coal Storage
30531090 Coal Mining, Cleaning, and Material Handling (See 305010), Haul Roads: General
30531099 Coal Mining, Cleaning, and Material Handling (See 305010), Other Not Classified
30532006 Stone Quarrying-Processing (See 305020), Misc. Operations
30532008 Stone Quarrying - Processing (See also 305020 for diff. units), Cut Stone: General
30588801 Fugitive Emissions, Specify in Comments Field
30588802 Fugitive Emissions, Specify in Comments Field
30588803 Fugitive Emissions, Specify in Comments Field
30588804 Fugitive Emissions, Specify in Comments Field
30588805 Fugitive Emissions, Specify in Comments Field
30590001 Fuel Fired Equipment, Distillate Oil (No. 2): Process Heaters
30590003 Fuel Fired Equipment, Natural Gas: Process Heaters
30590023 Fuel Fired Equipment, Natural Gas: Flares
30599999 Mineral Products, Other Not Defined, Specify in Comments Field

AT-A-GLANCE TABLE FOR POINT SOURCES

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 99% from uncontrolled for both PM10 and PM2.5

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs for mechanical shaker cleaned systems are generated using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan, 2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 2000). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$8 to \$71 per scfm
Typical value is \$29 per scfm

O&M Costs:

Range from \$4 to \$24 per scfm
Typical value is \$11 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). O&M costs were calculated for three model plants with flow rates of 25, 75 and 150 thousand acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust loading of 4.0 grains per cubic feet. The operating time was assumed to be 8760 hours per year. An average bag cost was estimated using the costs for standard bag

AT-A-GLANCE TABLE FOR POINT SOURCES

types. Capital recovery for the periodic replacement of bags was included in the O&M cost of the bags using a bag life of 2 years (EPA, 1998a). The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.0671	\$/kW-hr
Compressed air	0.25	\$/1000 scf
Dust disposal	25	\$/ton disposed

Note: All costs are in 1998 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$37 to \$303 per ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$126 per ton PM10 reduced. (1998\$)

Comments:

Status: Demonstrated	Last Reviewed: 2001
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Additional Information:

Materials handling operations including crushing, grinding, and screening, can produce significant PM emissions. Drying, the heating of minerals or mineral products to remove water, and calcination, heating to higher temperatures to remove chemically bound water and other compounds, are normally performed in dedicated, closed units. Emissions from these units will be through process vents, to which PM controls can be applied relatively simply. Fugitive dust emissions may come from paved and unpaved roads in plants and from raw material and product loading, unloading, and storage (STAPPA/ALAPCO, 1996).

Cost estimates assume a conventional design under typical operating conditions. The costs do not include auxiliary equipment such as fans and ductwork. (EPA, 2000)

Costs are primarily based on volumetric flow rate and the amount of PM in the waste stream. In general, a small unit controlling a low pollutant levels will not be as cost effective as a large unit controlling a high pollutant levels. (EPA, 2000)

Pollutants requiring a high level of control or the fabric filters to be constructed of special materials will increase the costs of the system (EPA, 1998a). The additional costs for controlling complex waste streams are not included in the estimates. For these systems, the capital cost could increase by as much as 30% and the O&M cost could increase by as much as 7%.

In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Fabric filters may be in the form of sheets, cartridges, or bags, with many individual filter units together in a group. Bags are the most common type of filter. The dust cake that forms on the filter from the collected PM can significantly increase collection efficiency. (EPA, 2000)

Mechanical shaking is a popular cleaning method because it is both simple and effective. In typical operation, dusty gas enters an inlet pipe to the fabric filter and very large particles are removed using a baffle plate fall into the hopper. The gas stream is drawn from beneath a cell plate in the floor and into the filter bags (EPA, 2000). The gas proceeds from the inside to the outside of the filter bags. The particles collect on the inside of the bags, forming a filter cake. In mechanical shaking units, the tops of bags are attached to a shaker bar, moved briskly (usually in a horizontal direction) to clean the bags. The shaker bars are operated by mechanical motors or by hand (EPA,

AT-A-GLANCE TABLE FOR POINT SOURCES

1998b)..

Fabric filters are useful for collecting particles with resistivities either too low or too high for collection with electrostatic precipitators. Fabric filters are useful in controlling particulate matter less than or equal to 10 micrometers (μm) in diameter (PM₁₀) and particulate matter less than or equal to 2.5 μm in diameter (PM_{2.5}). Fabric filters may be good candidates for collecting fly ash from low-sulfur coals or containing high unburned carbon levels and are relatively difficult to collect with electrostatic precipitators. (EPA, 2000)

References:

EPA, 1998a: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, Chapter 5, EPA 453/B-96-001, Research Triangle Park, NC. December 1998.

EPA, 1998b: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

EPA, 2000: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Fabric Filter - Mechanical Shaker Cleaned Type," August 2000.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

STAPPA/ALAPCO, 1996: State and Territorial Air Pollution Program Administrators - Association of Local Air Pollution Control Officials, Controlling Particulate Matter Under the Clean Air Act: A Menu of Options, Washington, DC, July 1996.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Mineral Products - Other

Control Measure Name: Dry ESP-Wire Plate Type

Rule Name: Not Applicable

Pechan Measure Code: P2213

POD: 221

Application: This control is the use of dry electrostatic precipitators (ESP) to reduce PM emissions. An ESP uses electrical forces to move particles in an exhaust stream onto collector plates. Electrodes in the center of the flow are maintained at high voltage and generate an electrical field forcing particles to the collector walls. In dry ESPs, the collectors are knocked by various mechanical means to dislodge the particulate, which slides downward into a hopper.

This control applies to mineral production operations not classified as cement operations, coat cleaning, or stone quarrying.

Affected SCC:

30500301 Mineral Products, Brick Manufacture, Raw Material Drying
30500302 Mineral Products, Brick Manufacture, Raw Material Grinding & Screening
30500303 Brick Manufacture, Storage of Raw Materials
30500305 Brick Manufacture, Raw Material Handling and Transferring
30500308 Brick Manufacture, Screening
30500309 Brick Manufacture, Blending and Mixing
30500310 Brick Manufacture, Curing and Firing: Sawdust Fired Tunnel Kilns
30500311 Mineral Products, Brick Manufacture, Curing and Firing: Gas-fired Tunnel Kilns
30500313 Mineral Products, Brick Manufacture, Curing and Firing: Coal-fired Tunnel Kilns
30500316 Brick Manufacture, Curing and Firing: Coal-fired Periodic Kilns
30500331 Brick Manufacture, Curing and Firing: Dual Fuel Fired Tunnel Kiln
30500398 Mineral Products, Brick Manufacture, Other Not Classified
30500399 Brick Manufacture, Other Not Classified
30500401 Calcium Carbide, Electric Furnace: Hoods and Main Stack
30500402 Mineral Products, Calcium Carbide, Coke Dryer
30500404 Calcium Carbide, Tap Fume Vents
30500406 Mineral Products, Calcium Carbide, Circular Charging: Conveyor
30500499 Mineral Products, Calcium Carbide, Other Not Classified
30500501 Castable Refractory, Fire Clay: Rotary Dryer
30500502 Castable Refractory, Raw Material Crushing/Processing
30500598 Castable Refractory, Other Not Classified
30500599 Castable Refractory, Other Not Classified
30500801 Ceramic Clay/Tile Manufacture, Drying ** (use SCC 3-05-008-13)
30500802 Mineral Products, Ceramic Clay/Tile, Comminution-Crushing, Grinding & Milling
30500803 Ceramic Clay/Tile Manufacture, Raw Material Storage
30500899 Mineral Products, Ceramic Clay/Tile Manufacture, Other Not Classified
30500901 Clay and Fly Ash Sintering, Fly Ash Sintering
30500902 Clay and Fly Ash Sintering, Clay/Coke Sintering
30500903 Clay and Fly Ash Sintering, Natural Clay/Shale Sintering
30500904 Clay and Fly Ash Sintering, Raw Clay/Shale Crushing/Screening
30500905 Clay and Fly Ash Sintering, Raw Clay/Shale Transfer/Conveying
30500908 Clay and Fly Ash Sintering, Sintered Clay/Shale Product Crushing/Screening
30500909 Clay and Fly Ash Sintering, Expanded Shale Clinker Cooling
30500910 Clay and Fly Ash Sintering, Expanded Shale Storage

AT-A-GLANCE TABLE FOR POINT SOURCES

30500915 Clay and Fly Ash Sintering, Rotary Kiln
30500999 Mineral Products, Clay and Fly Ash Sintering, Other Not Classified
30501101 Mineral Products, Concrete Batching, General (Non-fugitive)
30501106 Concrete Batching, Transfer: Sand/Aggregate to Elevated Bins
30501107 Concrete Batching, Cement Unloading: Storage Bins
30501108 Concrete Batching, Weight Hopper Loading of Cement/Sand/Aggregate
30501109 Mineral Products, Concrete Batching, Mixer Loading of Cement/Sand/Aggregate
30501110 Concrete Batching, Loading of Transit Mix Truck
30501111 Concrete Batching, Loading of Dry-batch Truck
30501112 Mineral Products, Concrete Batching, Mixing: Wet
30501113 Concrete Batching, Mixing: Dry
30501114 Concrete Batching, Transferring: Conveyors/Elevators
30501115 Concrete Batching, Storage: Bins/Hoppers
30501199 Mineral Products, Concrete Batching, Other Not Classified
30501201 Fiberglass Manufacturing, Regenerative Furnace (Wool-type Fiber)
30501203 Fiberglass Manufacturing, Electric Furnace (Wool-type Fiber)
30501204 Fiberglass Manufacturing, Forming: Rotary Spun (Wool-type Fiber)
30501205 Fiberglass Manufacturing, Curing Oven: Rotary Spun (Wool-type Fiber)
30501206 Fiberglass Manufacturing, Cooling (Wool-type Fiber)
30501207 Fiberglass Manufacturing, Unit Melter Furnace (Wool-type Fiber)
30501208 Fiberglass Manufacturing, Forming: Flame Attenuation (Wool-type Fiber)
30501209 Fiberglass Manufacturing, Curing: Flame Attenuation (Wool-type Fiber)
30501211 Fiberglass Manufacturing, Regenerative Furnace (Textile-type Fiber)
30501212 Fiberglass Manufacturing, Recuperative Furnace (Textile-type Fiber)
30501213 Fiberglass Manufacturing, Unit Melter Furnace (Textile-type Fiber)
30501214 Fiberglass Manufacturing, Forming Process (Textile-type Fiber)
30501215 Fiberglass Manufacturing, Curing Oven (Textile-type Fiber)
30501221 Fiberglass Manufacturing, Raw Material: Unloading/Conveying
30501223 Fiberglass Manufacturing, Raw Material: Mixing/Weighing
30501299 Mineral Products, Fiberglass Manufacturing, Other Not Classified
30501401 Glass Manufacture, Furnace/General**
30501402 Mineral Products, Glass Manufacture, Container Glass: Melting Furnace
30501403 Mineral Products, Glass Manufacture, Flat Glass: Melting Furnace
30501404 Glass Manufacture, Pressed and Blown Glass: Melting Furnace
30501406 Mineral Products, Glass Manufacture, Container Glass: Forming/Finishing
30501407 Glass Manufacture, Flat Glass: Forming/Finishing
30501408 Glass Manufacture, Pressed and Blown Glass: Forming/Finishing
30501410 Glass Manufacture, Raw Material Handling (All Types of Glass)
30501411 Glass Manufacture, General **
30501413 Mineral Products, Glass Manufacture, Cullet: Crushing/Grinding
30501415 Mineral Products, Glass Manufacture, Glass Etching with Hydrofluoric Acid Solution
30501416 Glass Manufacture, Glass Manufacturing
30501499 Glass Manufacture, See Comment **
30501501 Mineral Products, Gypsum Manufacture, Rotary Ore Dryer
30501502 Mineral Products, Gypsum Manufacture, Primary Grinder/Roller Mills
30501503 Gypsum Manufacture, Not Classified **
30501504 Mineral Products, Gypsum Manufacture, Conveying
30501505 Gypsum Manufacture, Primary Crushing: Gypsum Ore
30501506 Gypsum Manufacture, Secondary Crushing: Gypsum Ore
30501507 Gypsum Manufacture, Screening: Gypsum Ore
30501508 Mineral Products, Gypsum Manufacture, Stockpile: Gypsum Ore
30501509 Mineral Products, Gypsum Manufacture, Storage Bins: Gypsum Ore

AT-A-GLANCE TABLE FOR POINT SOURCES

30501511 Gypsum Manufacture, Continuous Kettle: Calciner
30501512 Gypsum Manufacture, Flash Calciner
30501513 Gypsum Manufacture, Impact Mill
30501514 Gypsum Manufacture, Storage Bins: Stucco
30501515 Gypsum Manufacture, Tube/Ball Mills
30501516 Gypsum Manufacture, Mixers
30501518 Mineral Products, Gypsum Manufacture, Mixers/Conveyors
30501519 Gypsum Manufacture, Forming Line
30501520 Mineral Products, Gypsum Manufacture, Drying Kiln
30501521 Mineral Products, Gypsum Manufacture, End Sawing (8 Ft.)
30501522 Mineral Products, Gypsum Manufacture, End Sawing (12 Ft.)
30501601 Lime Manufacture, Primary Crushing
30501602 Lime Manufacture, Secondary Crushing/Screening
30501603 Mineral Products, Lime Manufacture, Calcining: Vertical Kiln
30501604 Mineral Products, Lime Manufacture, Calcining: Rotary Kiln ** (See SCC Codes 3-05-016-18,-19,-20,-21)
30501605 Mineral Products, Lime Manufacture, Calcining: Gas-fired Calcimatic Kiln
30501607 Lime Manufacture, Raw Material Transfer and Conveying
30501608 Lime Manufacture, Raw Material Unloading
30501609 Lime Manufacture, Hydrator: Atmospheric
30501610 Lime Manufacture, Raw Material Storage Piles
30501611 Lime Manufacture, Product Cooler
30501612 Lime Manufacture, Pressure Hydrator
30501613 Mineral Products, Lime Manufacture, Lime Silos
30501614 Lime Manufacture, Packing/Shipping
30501615 Lime Manufacture, Product Transfer and Conveying
30501616 Lime Manufacture, Primary Screening
30501617 Lime Manufacture, Multiple Hearth Calciner
30501619 Lime Manufacture, Calcining: Gas-fired Rotary Kiln
30501620 Lime Manufacture, Calcining: Coal- and Gas-fired Rotary Kiln
30501626 Lime Manufacture, Product Loading, Enclosed Truck
30501640 Lime Manufacture, Vehicle Traffic
30501699 Lime Manufacture, See Comment **
30501701 Mineral Wool, Cupola
30501703 Mineral Wool, Blow Chamber
30501704 Mineral Wool, Curing Oven
30501705 Mineral Wool, Cooler
30501801 Perlite Manufacturing, Vertical Furnace
30501899 Perlite Manufacturing, Other Not Classified
30501901 Phosphate Rock, Drying
30501902 Phosphate Rock, Grinding
30501903 Phosphate Rock, Transfer/Storage
30501905 Mineral Products, Phosphate Rock, Calcining
30501906 Phosphate Rock, Rotary Dryer
30501999 Phosphate Rock, Other Not Classified
30502101 Salt Mining, General
30502201 Potash Production, Mine: Grinding/Drying
30502299 Potash Production, Other Not Classified
30502401 Magnesium Carbonate, Mine/Process
30502501 Construction Sand and Gravel, Total Plant: General **
30502502 Construction Sand and Gravel, Aggregate Storage
30502503 Construction Sand and Gravel, Material Transfer and Conveying

AT-A-GLANCE TABLE FOR POINT SOURCES

30502504 Construction Sand and Gravel, Hauling
30502505 Construction Sand and Gravel, Pile Forming: Stacker
30502506 Construction Sand and Gravel, Bulk Loading
30502507 Construction Sand and Gravel, Storage Piles
30502508 Construction Sand & Gravel, Dryer (See 305027-20 thru -24 for Industrial Sand Dryers)
30502509 Construction Sand and Gravel, Cooler ** (See 3-05-027-30 for Industrial Sand Coolers)
30502510 Mineral Products, Construction Sand and Gravel, Crushing
30502511 Construction Sand and Gravel, Screening
30502599 Construction Sand and Gravel, Not Classified **
30502601 Diatomaceous Earth, Handling
30502699 Diatomaceous Earth, Other Not Classified
30502701 Industrial Sand and Gravel, Primary Crushing of Raw Material
30502705 Industrial Sand and Gravel, Secondary Crushing
30502709 Industrial Sand and Gravel, Grinding: Size Reduction to 50 Microns or Smaller
30502713 Industrial Sand and Gravel, Screening: Size Classification
30502760 Industrial Sand and Gravel, Sand Handling, Transfer, and Storage
30503099 Ceramic Electric Parts, Other Not Classified
30503301 Vermiculite, General
30504001 Mining and Quarrying of Nonmetallic Minerals, Open Pit Blasting
30504002 Mining and Quarrying of Nonmetallic Minerals, Open Pit Drilling
30504003 Mining and Quarrying of Nonmetallic Minerals, Open Pit Cobbing
30504010 Mining and Quarrying of Nonmetallic Minerals, Underground Ventilation
30504020 Mining and Quarrying of Nonmetallic Minerals, Loading
30504021 Mineral Products, Mining and Quarrying of Nonmetallic Minerals, Convey/Haul Material
30504022 Mining and Quarrying of Nonmetallic Minerals, Convey/Haul Waste
30504023 Mining and Quarrying of Nonmetallic Minerals, Unloading
30504024 Mining and Quarrying of Nonmetallic Minerals, Overburden Stripping
30504025 Mining and Quarrying of Nonmetallic Minerals, Stockpiling
30504030 Mineral Products, Mining and Quarrying of Nonmetallic Minerals, Primary Crusher
30504031 Mineral Products, Mining and Quarrying of Nonmetallic Minerals, Secondary Crusher
30504033 Mining and Quarrying of Nonmetallic Minerals, Ore Dryer
30504034 Mining and Quarrying of Nonmetallic Minerals, Screening
30504036 Mining and Quarrying of Nonmetallic Minerals, Tailing Piles
30504099 Mining and Quarrying of Nonmetallic Minerals, Other Not Classified
30504140 Clay processing: Kaolin, Calcining, rotary calciner
30510001 Bulk Materials Elevators, Unloading
30510002 Bulk Materials Elevators, Loading
30510101 Bulk Materials Conveyors, Ammonium Sulfate
30510103 Bulk Materials Conveyors, Coal
30510104 Bulk Materials Conveyors, Coke
30510105 Bulk Materials Conveyors, Limestone
30510197 Bulk Materials Conveyors, Fertilizer: Specify in Comments
30510198 Bulk Materials Conveyors, Mineral: Specify in Comments
30510199 Bulk Materials Conveyors, Other Not Classified
30510202 Mineral Products, Bulk Materials Storage Bins, Cement
30510203 Bulk Materials Storage Bins, Coal
30510204 Bulk Materials Storage Bins, Coke
30510205 Bulk Materials Storage Bins, Limestone
30510298 Mineral Products, Bulk Materials Storage Bins, Mineral: Specify in Comments
30510299 Bulk Materials Storage Bins, Other Not Classified
30510303 Bulk Materials Open Stockpiles, Coal
30510304 Bulk Materials Open Stockpiles, Coke

AT-A-GLANCE TABLE FOR POINT SOURCES

30510397 Bulk Materials Open Stockpiles, Fertilizer: Specify in Comments
 30510398 Bulk Materials Open Stockpiles, Mineral: Specify in Comments
 30510399 Bulk Materials Open Stockpiles, Other Not Classified
 30510402 Bulk Materials Unloading Operation, Cement
 30510403 Mineral Products, Bulk Materials Unloading Operation, Coal
 30510404 Bulk Materials Unloading Operation, Coke
 30510405 Bulk Materials Unloading Operation, Limestone
 30510406 Bulk Materials Unloading Operation, Phosphate Rock
 30510407 Bulk Materials Unloading Operation, Scrap Metal
 30510497 Bulk Materials Unloading Operation, Fertilizer: Specify in Comments
 30510498 Bulk Materials Unloading Operation, Mineral: Specify in Comments
 30510499 Bulk Materials Unloading Operation, Other Not Classified
 30510503 Bulk Materials Loading Operation, Coal
 30510505 Bulk Materials Loading Operation, Limestone
 30510507 Bulk Materials Loading Operation, Scrap Metal
 30510596 Bulk Materials Loading Operation, Chemical: Specify in Comments
 30510597 Bulk Materials Loading Operation, Fertilizer: Specify in Comments
 30510598 Bulk Materials Loading Operation, Mineral: Specify in Comments
 30510599 Bulk Materials Loading Operation, Other Not Classified
 30515001 Calcining, Raw Material Handling
 30515002 Calcining, General
 30515004 Calcining, Finished Product Handling
 30531008 Coal Mining, Cleaning, and Material Handling (See 305010), Unloading
 30531009 Coal Mining, Cleaning, and Material Handling (See 305010), Raw Coal Storage
 30531010 Coal Mining, Cleaning, and Material Handling (See 305010), Crushing
 30531011 Coal Mining, Cleaning, and Material Handling (See 305010), Coal Transfer
 30531012 Coal Mining, Cleaning, and Material Handling (See 305010), Screening
 30531014 Coal Mining, Cleaning, and Material Handling (See 305010), Cleaned Coal Storage
 30531090 Coal Mining, Cleaning, and Material Handling (See 305010), Haul Roads: General
 30531099 Coal Mining, Cleaning, and Material Handling (See 305010), Other Not Classified
 30532006 Stone Quarrying-Processing (See 305020), Misc. Operations
 30532008 Stone Quarrying - Processing (See also 305020 for diff. units), Cut Stone: General
 30588801 Fugitive Emissions, Specify in Comments Field
 30588802 Fugitive Emissions, Specify in Comments Field
 30588803 Fugitive Emissions, Specify in Comments Field
 30588804 Fugitive Emissions, Specify in Comments Field
 30588805 Fugitive Emissions, Specify in Comments Field
 30590001 Fuel Fired Equipment, Distillate Oil (No. 2): Process Heaters
 30590003 Fuel Fired Equipment, Natural Gas: Process Heaters
 30590023 Fuel Fired Equipment, Natural Gas: Flares
 30599999 Mineral Products, Other Not Defined, Specify in Comments Field

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: PM10 control efficiency is 98% from uncontrolled; PM2.5 control efficiency is 95% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

AT-A-GLANCE TABLE FOR POINT SOURCES

Cost Basis: The costs for ESPs of conventional design under typical operating conditions are developed using EPA cost estimating spreadsheets (EPA, 1996). When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan, 2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 1999). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$15 to \$50 per scfm
Typical value is \$27 per scfm

O&M Costs:

Range from \$4 to \$40 per scfm
Typical value is \$16 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for ESP (EPA, 1996). O&M costs were calculated for three model plants with flow rates of 200 and 500 thousand acfm and 1 million acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust loading of 6.0 grains per cubic feet. The operating time was assumed to be 8640 hours per year. The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.067	\$/kW-hr
Dust disposal	25	\$/ton disposed

Note: All costs are in 1995 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$40 to \$250 per ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$110 per ton PM10 reduced. (1995\$)

AT-A-GLANCE TABLE FOR POINT SOURCES

Comments:**Status:** Demonstrated**Last Reviewed:** 2001

Additional Information:

Material handling operations including crushing, grinding, and screening, can produce significant PM emissions. Drying, the heating of minerals or mineral products to remove water, and calcination, heating to higher temperatures to remove chemically bound water and other compounds, are normally performed in dedicated, closed units. Emissions from these units will be through process vents, to which PM controls can be applied relatively simply.

In the wire-plate ESP, the gas flows around vertical, metal plates. The electrodes are long, weighted wires hanging between the plates. The voltage applied to the electrodes causes the gas between the electrodes to break down, known as a "corona." The electrodes are most often given a negative polarity because a negative corona supports a higher voltage than a positive corona.

Certain types of losses affect control efficiency. The dislodging of the accumulated layer also projects some of the particles back into the gas stream. These particles are processed in later sections of the ESP, but the particles from the last section have no chance to be recaptured. Due to the space needed at the top of the ESP for nonelectrified components, part of the stream may flow around the charged zones. This is called "sneakage" and places an upper limit on the collection efficiency of the ESP. Anti-sneakage baffles are used to force the sneakage flow to mix with the main gas stream for collection in later sections (EPA, 1998).

Another factor in the performance of ESPs is the resistivity of the collected material. All the ion current must pass through the collected layer to reach the ground plates. This creates an electric field in the layer, and it can become large enough to cause electrical breakdown. When this occurs, new ions of the wrong polarity are injected into the wire-plate gap reducing the charge on the particles, which may cause sparking. This condition is called "back corona." When this happens the collection ability of the unit is reduced. At low resistivities the particles are held on the plates so loosely that reentrainment levels are much higher. Hence, care must be taken in measuring or estimating resistivity because it is strongly affected by such variables as temperature, moisture, gas composition, particle composition, and surface characteristics (EPA, 1999).

Dusts with high resistivities are also not well-suited for collection in dry ESPs. These particles are not easily charged nor easily collected. High-resistivity particles form ash layers with very high voltage gradients on the collecting electrodes lead to back corona, reducing the charge on particles and lowering collection efficiency. Fly ash from the combustion of low-sulfur coal typically has a high resistivity, and thus is difficult to collect using dry ESPs (EPA, 1999).

References:

EPA, 1996: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, EPA 453/B-96-001, Research Triangle Park, NC. February 1996.

EPA, 1998: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

EPA, 1999: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Dry Electrostatic Precipitator (ESP) - Wire-Plate Type," May 1999.

AT-A-GLANCE TABLE FOR POINT SOURCES

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Mineral Products - Other

Control Measure Name: Wet ESP - Wire Plate Type

Rule Name: Not Applicable

Pechan Measure Code: P2214

POD: 221

Application: This control is the use of a wire-plate type electrostatic precipitator (ESP) to reduce PM emissions. An ESP uses electrical forces to move particles in an exhaust stream onto collector plates. Electrodes in the center of the flow are maintained at high voltage and generate an electrical field forcing particles to the collector walls. Wet ESPs use a stream of water, in place of rapping mechanisms, to dislodge particulate from the plates and into a sump.

This control applies to miscellaneous mineral production operations including (but not limited to) brick manufacture, calcium carbide operations, clay and fly ash sintering, concrete batching, gypsum manufacturing, lime production, phosphate rock operations, sand production, fiberglass manufacturing and glass manufacturing operations. Materials handling operations including crushing, grinding, and screening, can produce significant PM emissions.

Affected SCC:

30500301 Mineral Products, Brick Manufacture, Raw Material Drying
30500302 Mineral Products, Brick Manufacture, Raw Material Grinding & Screening
30500303 Brick Manufacture, Storage of Raw Materials
30500305 Brick Manufacture, Raw Material Handling and Transferring
30500308 Brick Manufacture, Screening
30500309 Brick Manufacture, Blending and Mixing
30500310 Brick Manufacture, Curing and Firing: Sawdust Fired Tunnel Kilns
30500311 Mineral Products, Brick Manufacture, Curing and Firing: Gas-fired Tunnel Kilns
30500313 Mineral Products, Brick Manufacture, Curing and Firing: Coal-fired Tunnel Kilns
30500316 Brick Manufacture, Curing and Firing: Coal-fired Periodic Kilns
30500331 Brick Manufacture, Curing and Firing: Dual Fuel Fired Tunnel Kiln
30500398 Mineral Products, Brick Manufacture, Other Not Classified
30500399 Brick Manufacture, Other Not Classified
30500401 Calcium Carbide, Electric Furnace: Hoods and Main Stack
30500402 Mineral Products, Calcium Carbide, Coke Dryer
30500404 Calcium Carbide, Tap Fume Vents
30500406 Mineral Products, Calcium Carbide, Circular Charging: Conveyor
30500499 Mineral Products, Calcium Carbide, Other Not Classified
30500501 Castable Refractory, Fire Clay: Rotary Dryer
30500502 Castable Refractory, Raw Material Crushing/Processing
30500598 Castable Refractory, Other Not Classified
30500599 Castable Refractory, Other Not Classified
30500801 Ceramic Clay/Tile Manufacture, Drying ** (use SCC 3-05-008-13)
30500802 Mineral Products, Ceramic Clay/Tile, Comminution-Crushing, Grinding & Milling
30500803 Ceramic Clay/Tile Manufacture, Raw Material Storage
30500805 Ceramic Clay/Tile Manufacture, Granulation-Mixing of Ceramic Powder & Binder Sol'n
30500899 Mineral Products, Ceramic Clay/Tile Manufacture, Other Not Classified
30500901 Clay and Fly Ash Sintering, Fly Ash Sintering
30500902 Clay and Fly Ash Sintering, Clay/Coke Sintering
30500903 Clay and Fly Ash Sintering, Natural Clay/Shale Sintering

AT-A-GLANCE TABLE FOR POINT SOURCES

30500904 Clay and Fly Ash Sintering, Raw Clay/Shale Crushing/Screening
30500905 Clay and Fly Ash Sintering, Raw Clay/Shale Transfer/Conveying
30500908 Clay and Fly Ash Sintering, Sintered Clay/Shale Product Crushing/Screening
30500909 Clay and Fly Ash Sintering, Expanded Shale Clinker Cooling
30500910 Clay and Fly Ash Sintering, Expanded Shale Storage
30500915 Clay and Fly Ash Sintering, Rotary Kiln
30500999 Mineral Products, Clay and Fly Ash Sintering, Other Not Classified
30501101 Mineral Products, Concrete Batching, General (Non-fugitive)
30501106 Concrete Batching, Transfer: Sand/Aggregate to Elevated Bins
30501107 Concrete Batching, Cement Unloading: Storage Bins
30501108 Concrete Batching, Weight Hopper Loading of Cement/Sand/Aggregate
30501109 Mineral Products, Concrete Batching, Mixer Loading of Cement/Sand/Aggregate
30501110 Concrete Batching, Loading of Transit Mix Truck
30501111 Concrete Batching, Loading of Dry-batch Truck
30501112 Mineral Products, Concrete Batching, Mixing: Wet
30501113 Concrete Batching, Mixing: Dry
30501114 Concrete Batching, Transferring: Conveyors/Elevators
30501115 Concrete Batching, Storage: Bins/Hoppers
30501199 Mineral Products, Concrete Batching, Other Not Classified
30501201 Fiberglass Manufacturing, Regenerative Furnace (Wool-type Fiber)
30501203 Fiberglass Manufacturing, Electric Furnace (Wool-type Fiber)
30501204 Fiberglass Manufacturing, Forming: Rotary Spun (Wool-type Fiber)
30501205 Fiberglass Manufacturing, Curing Oven: Rotary Spun (Wool-type Fiber)
30501206 Fiberglass Manufacturing, Cooling (Wool-type Fiber)
30501207 Fiberglass Manufacturing, Unit Melter Furnace (Wool-type Fiber)
30501208 Fiberglass Manufacturing, Forming: Flame Attenuation (Wool-type Fiber)
30501209 Fiberglass Manufacturing, Curing: Flame Attenuation (Wool-type Fiber)
30501211 Fiberglass Manufacturing, Regenerative Furnace (Textile-type Fiber)
30501212 Fiberglass Manufacturing, Recuperative Furnace (Textile-type Fiber)
30501213 Fiberglass Manufacturing, Unit Melter Furnace (Textile-type Fiber)
30501214 Fiberglass Manufacturing, Forming Process (Textile-type Fiber)
30501215 Fiberglass Manufacturing, Curing Oven (Textile-type Fiber)
30501221 Fiberglass Manufacturing, Raw Material: Unloading/Conveying
30501223 Fiberglass Manufacturing, Raw Material: Mixing/Weighing
30501299 Mineral Products, Fiberglass Manufacturing, Other Not Classified
30501401 Glass Manufacture, Furnace/General**
30501402 Mineral Products, Glass Manufacture, Container Glass: Melting Furnace
30501403 Mineral Products, Glass Manufacture, Flat Glass: Melting Furnace
30501404 Glass Manufacture, Pressed and Blown Glass: Melting Furnace
30501406 Mineral Products, Glass Manufacture, Container Glass: Forming/Finishing
30501407 Glass Manufacture, Flat Glass: Forming/Finishing
30501408 Glass Manufacture, Pressed and Blown Glass: Forming/Finishing
30501410 Glass Manufacture, Raw Material Handling (All Types of Glass)
30501411 Glass Manufacture, General **
30501413 Mineral Products, Glass Manufacture, Cullet: Crushing/Grinding
30501415 Mineral Products, Glass Manufacture, Glass Etching with Hydrofluoric Acid Solution
30501416 Glass Manufacture, Glass Manufacturing
30501499 Glass Manufacture, See Comment **
30501501 Mineral Products, Gypsum Manufacture, Rotary Ore Dryer
30501502 Mineral Products, Gypsum Manufacture, Primary Grinder/Roller Mills
30501503 Gypsum Manufacture, Not Classified **
30501504 Mineral Products, Gypsum Manufacture, Conveying

AT-A-GLANCE TABLE FOR POINT SOURCES

30501505 Gypsum Manufacture, Primary Crushing: Gypsum Ore
30501506 Gypsum Manufacture, Secondary Crushing: Gypsum Ore
30501507 Gypsum Manufacture, Screening: Gypsum Ore
30501508 Mineral Products, Gypsum Manufacture, Stockpile: Gypsum Ore
30501509 Mineral Products, Gypsum Manufacture, Storage Bins: Gypsum Ore
30501511 Gypsum Manufacture, Continuous Kettle: Calciner
30501512 Gypsum Manufacture, Flash Calciner
30501513 Gypsum Manufacture, Impact Mill
30501514 Gypsum Manufacture, Storage Bins: Stucco
30501515 Gypsum Manufacture, Tube/Ball Mills
30501516 Gypsum Manufacture, Mixers
30501518 Mineral Products, Gypsum Manufacture, Mixers/Conveyors
30501519 Gypsum Manufacture, Forming Line
30501520 Mineral Products, Gypsum Manufacture, Drying Kiln
30501521 Mineral Products, Gypsum Manufacture, End Sawing (8 Ft.)
30501522 Mineral Products, Gypsum Manufacture, End Sawing (12 Ft.)
30501601 Lime Manufacture, Primary Crushing
30501602 Lime Manufacture, Secondary Crushing/Screening
30501603 Mineral Products, Lime Manufacture, Calcining: Vertical Kiln
30501604 Mineral Products, Lime Manufacture, Calcining: Rotary Kiln ** (See SCC Codes 3-05-016-18,-19,-20,-21)
30501605 Mineral Products, Lime Manufacture, Calcining: Gas-fired Calcimatic Kiln
30501606 Lime Manufacture, Fluidized Bed Kiln
30501607 Lime Manufacture, Raw Material Transfer and Conveying
30501608 Lime Manufacture, Raw Material Unloading
30501609 Lime Manufacture, Hydrator: Atmospheric
30501610 Lime Manufacture, Raw Material Storage Piles
30501611 Lime Manufacture, Product Cooler
30501612 Lime Manufacture, Pressure Hydrator
30501613 Mineral Products, Lime Manufacture, Lime Silos
30501614 Lime Manufacture, Packing/Shipping
30501615 Lime Manufacture, Product Transfer and Conveying
30501616 Lime Manufacture, Primary Screening
30501617 Lime Manufacture, Multiple Hearth Calciner
30501619 Lime Manufacture, Calcining: Gas-fired Rotary Kiln
30501620 Lime Manufacture, Calcining: Coal- and Gas-fired Rotary Kiln
30501626 Lime Manufacture, Product Loading, Enclosed Truck
30501640 Lime Manufacture, Vehicle Traffic
30501699 Lime Manufacture, See Comment **
30501701 Mineral Wool, Cupola
30501703 Mineral Wool, Blow Chamber
30501704 Mineral Wool, Curing Oven
30501705 Mineral Wool, Cooler
30501799 Mineral Wool, Other Not Classified
30501801 Perlite Manufacturing, Vertical Furnace
30501899 Perlite Manufacturing, Other Not Classified
30501901 Phosphate Rock, Drying
30501902 Phosphate Rock, Grinding
30501903 Phosphate Rock, Transfer/Storage
30501905 Mineral Products, Phosphate Rock, Calcining
30501906 Phosphate Rock, Rotary Dryer
30501907 Phosphate Rock, Ball Mill

AT-A-GLANCE TABLE FOR POINT SOURCES

30501999 Phosphate Rock, Other Not Classified
30502101 Salt Mining, General
30502201 Potash Production, Mine: Grinding/Drying
30502299 Potash Production, Other Not Classified
30502401 Magnesium Carbonate, Mine/Process
30502501 Construction Sand and Gravel, Total Plant: General **
30502502 Construction Sand and Gravel, Aggregate Storage
30502503 Construction Sand and Gravel, Material Transfer and Conveying
30502504 Construction Sand and Gravel, Hauling
30502505 Construction Sand and Gravel, Pile Forming: Stacker
30502506 Construction Sand and Gravel, Bulk Loading
30502507 Construction Sand and Gravel, Storage Piles
30502508 Construction Sand & Gravel, Dryer (See 305027-20 thru -24 for Industrial Sand Dryers)
30502509 Construction Sand & Gravel, Cooler (See 305027-30 for Industrial Sand Coolers)
30502510 Mineral Products, Construction Sand and Gravel, Crushing
30502511 Construction Sand and Gravel, Screening
30502599 Construction Sand and Gravel, Not Classified **
30502601 Diatomaceous Earth, Handling
30502699 Diatomaceous Earth, Other Not Classified
30502701 Industrial Sand and Gravel, Primary Crushing of Raw Material
30502705 Industrial Sand and Gravel, Secondary Crushing
30502709 Industrial Sand and Gravel, Grinding: Size Reduction to 50 Microns or Smaller
30502713 Industrial Sand and Gravel, Screening: Size Classification
30502760 Industrial Sand and Gravel, Sand Handling, Transfer, and Storage
30503099 Ceramic Electric Parts, Other Not Classified
30503301 Vermiculite, General
30504001 Mining and Quarrying of Nonmetallic Minerals, Open Pit Blasting
30504002 Mining and Quarrying of Nonmetallic Minerals, Open Pit Drilling
30504003 Mining and Quarrying of Nonmetallic Minerals, Open Pit Cobbing
30504010 Mining and Quarrying of Nonmetallic Minerals, Underground Ventilation
30504020 Mining and Quarrying of Nonmetallic Minerals, Loading
30504021 Mineral Products, Mining and Quarrying of Nonmetallic Minerals, Convey/Haul Material
30504022 Mining and Quarrying of Nonmetallic Minerals, Convey/Haul Waste
30504023 Mining and Quarrying of Nonmetallic Minerals, Unloading
30504024 Mining and Quarrying of Nonmetallic Minerals, Overburden Stripping
30504025 Mining and Quarrying of Nonmetallic Minerals, Stockpiling
30504030 Mineral Products, Mining and Quarrying of Nonmetallic Minerals, Primary Crusher
30504031 Mineral Products, Mining and Quarrying of Nonmetallic Minerals, Secondary Crusher
30504033 Mining and Quarrying of Nonmetallic Minerals, Ore Dryer
30504034 Mining and Quarrying of Nonmetallic Minerals, Screening
30504036 Mining and Quarrying of Nonmetallic Minerals, Tailing Piles
30504099 Mining and Quarrying of Nonmetallic Minerals, Other Not Classified
30504140 Clay processing: Kaolin, Calcining, rotary calciner
30510001 Bulk Materials Elevators, Unloading
30510002 Bulk Materials Elevators, Loading
30510101 Bulk Materials Conveyors, Ammonium Sulfate
30510103 Bulk Materials Conveyors, Coal
30510104 Bulk Materials Conveyors, Coke
30510105 Bulk Materials Conveyors, Limestone
30510197 Bulk Materials Conveyors, Fertilizer: Specify in Comments
30510198 Bulk Materials Conveyors, Mineral: Specify in Comments
30510199 Bulk Materials Conveyors, Other Not Classified

AT-A-GLANCE TABLE FOR POINT SOURCES

30510202 Mineral Products, Bulk Materials Storage Bins, Cement
30510203 Bulk Materials Storage Bins, Coal
30510204 Bulk Materials Storage Bins, Coke
30510205 Bulk Materials Storage Bins, Limestone
30510298 Mineral Products, Bulk Materials Storage Bins, Mineral: Specify in Comments
30510299 Bulk Materials Storage Bins, Other Not Classified
30510303 Bulk Materials Open Stockpiles, Coal
30510304 Bulk Materials Open Stockpiles, Coke
30510397 Bulk Materials Open Stockpiles, Fertilizer: Specify in Comments
30510398 Bulk Materials Open Stockpiles, Mineral: Specify in Comments
30510399 Bulk Materials Open Stockpiles, Other Not Classified
30510402 Bulk Materials Unloading Operation, Cement
30510403 Mineral Products, Bulk Materials Unloading Operation, Coal
30510404 Bulk Materials Unloading Operation, Coke
30510405 Bulk Materials Unloading Operation, Limestone
30510406 Bulk Materials Unloading Operation, Phosphate Rock
30510407 Bulk Materials Unloading Operation, Scrap Metal
30510497 Bulk Materials Unloading Operation, Fertilizer: Specify in Comments
30510498 Bulk Materials Unloading Operation, Mineral: Specify in Comments
30510499 Bulk Materials Unloading Operation, Other Not Classified
30510503 Bulk Materials Loading Operation, Coal
30510505 Bulk Materials Loading Operation, Limestone
30510507 Bulk Materials Loading Operation, Scrap Metal
30510596 Bulk Materials Loading Operation, Chemical: Specify in Comments
30510597 Bulk Materials Loading Operation, Fertilizer: Specify in Comments
30510598 Bulk Materials Loading Operation, Mineral: Specify in Comments
30510599 Bulk Materials Loading Operation, Other Not Classified
30515001 Calcining, Raw Material Handling
30515002 Calcining, General
30515004 Calcining, Finished Product Handling
30531008 Coal Mining, Cleaning, and Material Handling (See 305010), Unloading
30531009 Coal Mining, Cleaning, and Material Handling (See 305010), Raw Coal Storage
30531010 Coal Mining, Cleaning, and Material Handling (See 305010), Crushing
30531011 Coal Mining, Cleaning, and Material Handling (See 305010), Coal Transfer
30531012 Coal Mining, Cleaning, and Material Handling (See 305010), Screening
30531014 Coal Mining, Cleaning, and Material Handling (See 305010), Cleaned Coal Storage
30531090 Coal Mining, Cleaning, and Material Handling (See 305010), Haul Roads: General
30531099 Coal Mining, Cleaning, and Material Handling (See 305010), Other Not Classified
30532006 Stone Quarrying-Processing (See 305020), Misc. Operations
30532008 Stone Quarrying - Processing (See also 305020 for diff. units), Cut Stone: General
30588801 Fugitive Emissions, Specify in Comments Field
30588802 Fugitive Emissions, Specify in Comments Field
30588803 Fugitive Emissions, Specify in Comments Field
30588804 Fugitive Emissions, Specify in Comments Field
30588805 Fugitive Emissions, Specify in Comments Field
30590001 Fuel Fired Equipment, Distillate Oil (No. 2): Process Heaters
30590003 Fuel Fired Equipment, Natural Gas: Process Heaters
30590023 Fuel Fired Equipment, Natural Gas: Flares
30599999 Mineral Products, Other Not Defined, Specify in Comments Field

AT-A-GLANCE TABLE FOR POINT SOURCES

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: PM10 control efficiency is 99% from uncontrolled; PM2.5 control efficiency is 95% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The following are cost ranges for wire-plate ESPs, developed using EPA cost-estimating spreadsheets for dry wire-plate ESPs with adjustments made to reflect wet wire-plate ESPs (EPA, 1999). Capital and operating costs are generally higher due to noncorrosive materials requirements, increased water usage, and treatment and disposal of wet effluent. When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan,2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 1990). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$30 to \$60 per scfm
Typical value is \$40 per scfm

O&M Costs:

Range from \$6 to \$45 per scfm
Typical value is \$19 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for ESP (EPA, 1999). O&M costs were calculated for three model plants with flow rates of 10, 15 and 20

AT-A-GLANCE TABLE FOR POINT SOURCES

thousand acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust loading of 6.0 grains per cubic feet. The operating time was assumed to be 8640 hours per year. A water flow rate for the ESP was assumed to be 5 gal/min per thousand acfm. The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.067	\$/kW-hr
Process water price	0.20	\$/1000 gal
Dust disposal	20	\$/ton disposed
Wastewater treatment	1.5	\$/ thousand gal treated

Note: All costs are in 1995 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$55 to \$550 per ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$220 per ton PM10 reduced. (1995\$)

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

Materials handling operations including crushing, grinding, and screening, can produce significant PM emissions. Drying, the heating of minerals or mineral products to remove water, and calcination, heating to higher temperatures to remove chemically bound water and other compounds, are normally performed in dedicated, closed units. Emissions from these units will be through process vents, to which PM controls can be applied relatively simply. Fugitive dust emissions may come from paved and unpaved roads in plants and from raw material and product loading, unloading, and storage (STAPPA/ALAPCO, 1996).

Costs can be substantially higher than in the ranges shown for pollutants which require an unusually high level of control, or which require the ESP to be constructed of special materials such as titanium (EPA, 1999). In most cases, smaller units controlling a low concentration waste stream will not be as cost effective as a large unit cleaning a high pollutant load flow (EPA, 1998).

In the wire-plate ESP, the gas flows around vertical, metal plates. The electrodes are long, weighted wires hanging between the plates. The voltage applied to the electrodes causes the gas between the electrodes to break down, known as a "corona." The electrodes are most often given a negative polarity because a negative corona supports a higher voltage than a positive corona.

Certain types of losses affect control efficiency. The dislodging of the accumulated layer also projects some of the particles back into the gas stream. These particles are processed in later sections of the ESP, but the particles from the last section have no chance to be recaptured. Due to the space needed at the top of the ESP for nonelectrified components, part of the stream may flow around the charged zones. This is called "sneakage" and places an upper limit on the collection efficiency of the ESP. Anti-sneakage baffles are used to force the sneakage flow to mix with the main gas stream for collection in later sections (EPA, 1998).

Wire-Plate Type Wet ESPs require a source of wash water near the top of the collector plates. This wash system replaces the rapping mechanism used by dry ESPs. The water flows with the collected particles into a sump from which the fluid is pumped or drained. A portion of the fluid may be recycled to reduce the total amount of water required. The remainder is pumped into a settling pond

AT-A-GLANCE TABLE FOR POINT SOURCES

or passed through a dewatering stage, with subsequent disposal of the sludge (AWMA, 1992).

Unlike dry ESPs, resistivity of the collected material is not a major factor in performance. Because of the high humidity in a wet ESP, the resistivity of particles is lowered, eliminating the "back corona" condition. The frequent washing of the plates also limits particle buildup on the collectors (EPA, 1998).

For wet ESPs, the handling wastewaters must be considered (EPA, 1999). For simple systems with innocuous dusts, water with particles collected by the ESP may be discharged from the ESP system to a solids-removing clarifier. More complicated systems may require skimming and sludge removal, clarification in dedicated equipment, pH adjustment, and/or treatment to remove dissolved solids. Recirculation of treated water to the ESP may approach 100 percent (AWMA, 1992).

References:

AWMA, 1992: Air & Waste Management Association, Air Pollution Engineering Manual, Van Nostrand Reinhold, New York.

EPA, 1996: U.S. EPA, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, EPA 453/B-96-001, Research Triangle Park, NC. February.

EPA, 1998: U.S. EPA, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October.

EPA, 1999: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Wet Electrostatic Precipitator (ESP) - Wire-Plate Type," May 1999

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

STAPPA/ALAPCO, 1996: State and Territorial Air Pollution Program Administrators - Association of Local Air Pollution Control Officials, "Controlling Particulate Matter Under the Clean Air Act: A Menu of Options", Washington, DC, July 1996.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Mineral Products - Other

Control Measure Name: Paper/Nonwoven Filters - Cartridge Collector Type

Rule Name: Not Applicable

Pechan Measure Code: P2215

POD: 221

Application: This control is the use of paper or non-woven filters (cartridge collector type) to reduce PM emissions. The waste gas stream is passed through the fibrous filter media causing PM in the gas stream to be collected on the media by sieving and other mechanisms.

This control applies to miscellaneous mineral production operations including (but not limited to) brick manufacture, calcium carbide operations, clay and fly ash sintering, concrete batching, gypsum manufacturing, lime production, phosphate rock operations, sand production, fiberglass manufacturing and glass manufacturing operations. Materials handling operations including crushing, grinding, and screening, can produce significant PM emissions.

Affected SCC:

30500301 Mineral Products, Brick Manufacture, Raw Material Drying
30500302 Mineral Products, Brick Manufacture, Raw Material Grinding & Screening
30500303 Brick Manufacture, Storage of Raw Materials
30500305 Brick Manufacture, Raw Material Handling and Transferring
30500308 Brick Manufacture, Screening
30500309 Brick Manufacture, Blending and Mixing
30500310 Brick Manufacture, Curing and Firing: Sawdust Fired Tunnel Kilns
30500311 Mineral Products, Brick Manufacture, Curing and Firing: Gas-fired Tunnel Kilns
30500313 Mineral Products, Brick Manufacture, Curing and Firing: Coal-fired Tunnel Kilns
30500316 Brick Manufacture, Curing and Firing: Coal-fired Periodic Kilns
30500331 Brick Manufacture, Curing and Firing: Dual Fuel Fired Tunnel Kiln
30500398 Mineral Products, Brick Manufacture, Other Not Classified
30500399 Brick Manufacture, Other Not Classified
30500401 Calcium Carbide, Electric Furnace: Hoods and Main Stack
30500402 Mineral Products, Calcium Carbide, Coke Dryer
30500404 Calcium Carbide, Tap Fume Vents
30500406 Mineral Products, Calcium Carbide, Circular Charging: Conveyor
30500499 Mineral Products, Calcium Carbide, Other Not Classified
30500501 Castable Refractory, Fire Clay: Rotary Dryer
30500502 Castable Refractory, Raw Material Crushing/Processing
30500598 Castable Refractory, Other Not Classified
30500599 Castable Refractory, Other Not Classified
30500801 Ceramic Clay/Tile Manufacture, Drying ** (use SCC 3-05-008-13)
30500802 Mineral Products, Ceramic Clay/Tile, Comminution-Crushing, Grinding & Milling
30500803 Ceramic Clay/Tile Manufacture, Raw Material Storage
30500805 Ceramic Clay/Tile Manufacture, Granulation-Mixing of Ceramic Powder & Binder Sol'n
30500899 Mineral Products, Ceramic Clay/Tile Manufacture, Other Not Classified
30500901 Clay and Fly Ash Sintering, Fly Ash Sintering
30500902 Clay and Fly Ash Sintering, Clay/Coke Sintering
30500903 Clay and Fly Ash Sintering, Natural Clay/Shale Sintering
30500904 Clay and Fly Ash Sintering, Raw Clay/Shale Crushing/Screening
30500905 Clay and Fly Ash Sintering, Raw Clay/Shale Transfer/Conveying

AT-A-GLANCE TABLE FOR POINT SOURCES

30500908 Clay and Fly Ash Sintering, Sintered Clay/Shale Product Crushing/Screening
30500909 Clay and Fly Ash Sintering, Expanded Shale Clinker Cooling
30500910 Clay and Fly Ash Sintering, Expanded Shale Storage
30500915 Clay and Fly Ash Sintering, Rotary Kiln
30500999 Mineral Products, Clay and Fly Ash Sintering, Other Not Classified
30501101 Mineral Products, Concrete Batching, General (Non-fugitive)
30501106 Concrete Batching, Transfer: Sand/Aggregate to Elevated Bins
30501107 Concrete Batching, Cement Unloading: Storage Bins
30501108 Concrete Batching, Weight Hopper Loading of Cement/Sand/Aggregate
30501109 Mineral Products, Concrete Batching, Mixer Loading of Cement/Sand/Aggregate
30501110 Concrete Batching, Loading of Transit Mix Truck
30501111 Concrete Batching, Loading of Dry-batch Truck
30501112 Mineral Products, Concrete Batching, Mixing: Wet
30501113 Concrete Batching, Mixing: Dry
30501114 Concrete Batching, Transferring: Conveyors/Elevators
30501115 Concrete Batching, Storage: Bins/Hoppers
30501199 Mineral Products, Concrete Batching, Other Not Classified
30501201 Fiberglass Manufacturing, Regenerative Furnace (Wool-type Fiber)
30501203 Fiberglass Manufacturing, Electric Furnace (Wool-type Fiber)
30501204 Fiberglass Manufacturing, Forming: Rotary Spun (Wool-type Fiber)
30501205 Fiberglass Manufacturing, Curing Oven: Rotary Spun (Wool-type Fiber)
30501206 Fiberglass Manufacturing, Cooling (Wool-type Fiber)
30501207 Fiberglass Manufacturing, Unit Melter Furnace (Wool-type Fiber)
30501208 Fiberglass Manufacturing, Forming: Flame Attenuation (Wool-type Fiber)
30501209 Fiberglass Manufacturing, Curing: Flame Attenuation (Wool-type Fiber)
30501211 Fiberglass Manufacturing, Regenerative Furnace (Textile-type Fiber)
30501212 Fiberglass Manufacturing, Recuperative Furnace (Textile-type Fiber)
30501213 Fiberglass Manufacturing, Unit Melter Furnace (Textile-type Fiber)
30501214 Fiberglass Manufacturing, Forming Process (Textile-type Fiber)
30501215 Fiberglass Manufacturing, Curing Oven (Textile-type Fiber)
30501221 Fiberglass Manufacturing, Raw Material: Unloading/Conveying
30501223 Fiberglass Manufacturing, Raw Material: Mixing/Weighing
30501299 Mineral Products, Fiberglass Manufacturing, Other Not Classified
30501401 Glass Manufacture, Furnace/General**
30501402 Mineral Products, Glass Manufacture, Container Glass: Melting Furnace
30501403 Mineral Products, Glass Manufacture, Flat Glass: Melting Furnace
30501404 Glass Manufacture, Pressed and Blown Glass: Melting Furnace
30501406 Mineral Products, Glass Manufacture, Container Glass: Forming/Finishing
30501407 Glass Manufacture, Flat Glass: Forming/Finishing
30501408 Glass Manufacture, Pressed and Blown Glass: Forming/Finishing
30501410 Glass Manufacture, Raw Material Handling (All Types of Glass)
30501411 Glass Manufacture, General **
30501413 Mineral Products, Glass Manufacture, Cullet: Crushing/Grinding
30501415 Mineral Products, Glass Manufacture, Glass Etching with Hydrofluoric Acid Solution
30501416 Glass Manufacture, Glass Manufacturing
30501499 Glass Manufacture, See Comment **
30501501 Mineral Products, Gypsum Manufacture, Rotary Ore Dryer
30501502 Mineral Products, Gypsum Manufacture, Primary Grinder/Roller Mills
30501503 Gypsum Manufacture, Not Classified **
30501504 Mineral Products, Gypsum Manufacture, Conveying
30501505 Gypsum Manufacture, Primary Crushing: Gypsum Ore
30501506 Gypsum Manufacture, Secondary Crushing: Gypsum Ore

AT-A-GLANCE TABLE FOR POINT SOURCES

30501507 Gypsum Manufacture, Screening: Gypsum Ore
30501508 Mineral Products, Gypsum Manufacture, Stockpile: Gypsum Ore
30501509 Mineral Products, Gypsum Manufacture, Storage Bins: Gypsum Ore
30501511 Gypsum Manufacture, Continuous Kettle: Calciner
30501512 Gypsum Manufacture, Flash Calciner
30501513 Gypsum Manufacture, Impact Mill
30501514 Gypsum Manufacture, Storage Bins: Stucco
30501515 Gypsum Manufacture, Tube/Ball Mills
30501516 Gypsum Manufacture, Mixers
30501518 Mineral Products, Gypsum Manufacture, Mixers/Conveyors
30501519 Gypsum Manufacture, Forming Line
30501520 Mineral Products, Gypsum Manufacture, Drying Kiln
30501521 Mineral Products, Gypsum Manufacture, End Sawing (8 Ft.)
30501522 Mineral Products, Gypsum Manufacture, End Sawing (12 Ft.)
30501601 Lime Manufacture, Primary Crushing
30501602 Lime Manufacture, Secondary Crushing/Screening
30501603 Mineral Products, Lime Manufacture, Calcining: Vertical Kiln
30501604 Mineral Products, Lime Manufacture, Calcining: Rotary Kiln ** (See SCC Codes 3-05-016-18,-19,-20,-21)
30501605 Mineral Products, Lime Manufacture, Calcining: Gas-fired Calcimatic Kiln
30501606 Lime Manufacture, Fluidized Bed Kiln
30501607 Lime Manufacture, Raw Material Transfer and Conveying
30501608 Lime Manufacture, Raw Material Unloading
30501609 Lime Manufacture, Hydrator: Atmospheric
30501610 Lime Manufacture, Raw Material Storage Piles
30501611 Lime Manufacture, Product Cooler
30501612 Lime Manufacture, Pressure Hydrator
30501613 Mineral Products, Lime Manufacture, Lime Silos
30501614 Lime Manufacture, Packing/Shipping
30501615 Lime Manufacture, Product Transfer and Conveying
30501616 Lime Manufacture, Primary Screening
30501617 Lime Manufacture, Multiple Hearth Calciner
30501619 Lime Manufacture, Calcining: Gas-fired Rotary Kiln
30501620 Lime Manufacture, Calcining: Coal- and Gas-fired Rotary Kiln
30501626 Lime Manufacture, Product Loading, Enclosed Truck
30501640 Lime Manufacture, Vehicle Traffic
30501699 Lime Manufacture, See Comment **
30501701 Mineral Wool, Cupola
30501703 Mineral Wool, Blow Chamber
30501704 Mineral Wool, Curing Oven
30501705 Mineral Wool, Cooler
30501799 Mineral Wool, Other Not Classified
30501801 Perlite Manufacturing, Vertical Furnace
30501899 Perlite Manufacturing, Other Not Classified
30501901 Phosphate Rock, Drying
30501902 Phosphate Rock, Grinding
30501903 Phosphate Rock, Transfer/Storage
30501905 Mineral Products, Phosphate Rock, Calcining
30501906 Phosphate Rock, Rotary Dryer
30501907 Phosphate Rock, Ball Mill
30501999 Phosphate Rock, Other Not Classified
30502101 Salt Mining, General

AT-A-GLANCE TABLE FOR POINT SOURCES

30502201 Potash Production, Mine: Grinding/Drying
30502299 Potash Production, Other Not Classified
30502401 Magnesium Carbonate, Mine/Process
30502501 Construction Sand and Gravel, Total Plant: General **
30502502 Construction Sand and Gravel, Aggregate Storage
30502503 Construction Sand and Gravel, Material Transfer and Conveying
30502504 Construction Sand and Gravel, Hauling
30502505 Construction Sand and Gravel, Pile Forming: Stacker
30502506 Construction Sand and Gravel, Bulk Loading
30502507 Construction Sand and Gravel, Storage Piles
30502508 Construction Sand & Gravel, Dryer (See 305027-20 thru -24 for Industrial Sand Dryers)
30502509 Construction Sand and Gravel, Cooler ** (See 3-05-027-30 for Industrial Sand Coolers)
30502510 Mineral Products, Construction Sand and Gravel, Crushing
30502511 Construction Sand and Gravel, Screening
30502599 Construction Sand and Gravel, Not Classified **
30502601 Diatomaceous Earth, Handling
30502699 Diatomaceous Earth, Other Not Classified
30502701 Industrial Sand and Gravel, Primary Crushing of Raw Material
30502705 Industrial Sand and Gravel, Secondary Crushing
30502709 Industrial Sand and Gravel, Grinding: Size Reduction to 50 Microns or Smaller
30502713 Industrial Sand and Gravel, Screening: Size Classification
30502760 Industrial Sand and Gravel, Sand Handling, Transfer, and Storage
30503099 Ceramic Electric Parts, Other Not Classified
30503301 Vermiculite, General
30504001 Mining and Quarrying of Nonmetallic Minerals, Open Pit Blasting
30504002 Mining and Quarrying of Nonmetallic Minerals, Open Pit Drilling
30504003 Mining and Quarrying of Nonmetallic Minerals, Open Pit Cobbing
30504010 Mining and Quarrying of Nonmetallic Minerals, Underground Ventilation
30504020 Mining and Quarrying of Nonmetallic Minerals, Loading
30504021 Mineral Products, Mining and Quarrying of Nonmetallic Minerals, Convey/Haul Material
30504022 Mining and Quarrying of Nonmetallic Minerals, Convey/Haul Waste
30504023 Mining and Quarrying of Nonmetallic Minerals, Unloading
30504024 Mining and Quarrying of Nonmetallic Minerals, Overburden Stripping
30504025 Mining and Quarrying of Nonmetallic Minerals, Stockpiling
30504030 Mineral Products, Mining and Quarrying of Nonmetallic Minerals, Primary Crusher
30504031 Mineral Products, Mining and Quarrying of Nonmetallic Minerals, Secondary Crusher
30504033 Mining and Quarrying of Nonmetallic Minerals, Ore Dryer
30504034 Mining and Quarrying of Nonmetallic Minerals, Screening
30504036 Mining and Quarrying of Nonmetallic Minerals, Tailing Piles
30504099 Mining and Quarrying of Nonmetallic Minerals, Other Not Classified
30504140 Clay processing: Kaolin, Calcining, rotary calciner
30510001 Bulk Materials Elevators, Unloading
30510002 Bulk Materials Elevators, Loading
30510101 Bulk Materials Conveyors, Ammonium Sulfate
30510103 Bulk Materials Conveyors, Coal
30510104 Bulk Materials Conveyors, Coke
30510105 Bulk Materials Conveyors, Limestone
30510197 Bulk Materials Conveyors, Fertilizer: Specify in Comments
30510198 Bulk Materials Conveyors, Mineral: Specify in Comments
30510199 Bulk Materials Conveyors, Other Not Classified
30510202 Mineral Products, Bulk Materials Storage Bins, Cement
30510203 Bulk Materials Storage Bins, Coal

AT-A-GLANCE TABLE FOR POINT SOURCES

30510204 Bulk Materials Storage Bins, Coke
 30510205 Bulk Materials Storage Bins, Limestone
 30510298 Mineral Products, Bulk Materials Storage Bins, Mineral: Specify in Comments
 30510299 Bulk Materials Storage Bins, Other Not Classified
 30510303 Bulk Materials Open Stockpiles, Coal
 30510304 Bulk Materials Open Stockpiles, Coke
 30510397 Bulk Materials Open Stockpiles, Fertilizer: Specify in Comments
 30510398 Bulk Materials Open Stockpiles, Mineral: Specify in Comments
 30510399 Bulk Materials Open Stockpiles, Other Not Classified
 30510402 Bulk Materials Unloading Operation, Cement
 30510403 Mineral Products, Bulk Materials Unloading Operation, Coal
 30510404 Bulk Materials Unloading Operation, Coke
 30510405 Bulk Materials Unloading Operation, Limestone
 30510406 Bulk Materials Unloading Operation, Phosphate Rock
 30510407 Bulk Materials Unloading Operation, Scrap Metal
 30510497 Bulk Materials Unloading Operation, Fertilizer: Specify in Comments
 30510498 Bulk Materials Unloading Operation, Mineral: Specify in Comments
 30510499 Bulk Materials Unloading Operation, Other Not Classified
 30510503 Bulk Materials Loading Operation, Coal
 30510505 Bulk Materials Loading Operation, Limestone
 30510507 Bulk Materials Loading Operation, Scrap Metal
 30510596 Bulk Materials Loading Operation, Chemical: Specify in Comments
 30510597 Bulk Materials Loading Operation, Fertilizer: Specify in Comments
 30510598 Bulk Materials Loading Operation, Mineral: Specify in Comments
 30510599 Bulk Materials Loading Operation, Other Not Classified
 30515001 Calcining, Raw Material Handling
 30515002 Calcining, General
 30515004 Calcining, Finished Product Handling
 30531008 Coal Mining, Cleaning, and Material Handling (See 305010), Unloading
 30531009 Coal Mining, Cleaning, and Material Handling (See 305010), Raw Coal Storage
 30531010 Coal Mining, Cleaning, and Material Handling (See 305010), Crushing
 30531011 Coal Mining, Cleaning, and Material Handling (See 305010), Coal Transfer
 30531012 Coal Mining, Cleaning, and Material Handling (See 305010), Screening
 30531014 Coal Mining, Cleaning, and Material Handling (See 305010), Cleaned Coal Storage
 30531090 Coal Mining, Cleaning, and Material Handling (See 305010), Haul Roads: General
 30531099 Coal Mining, Cleaning, and Material Handling (See 305010), Other Not Classified
 30532006 Stone Quarrying-Processing (See 305020), Misc. Operations
 30532008 Stone Quarrying - Processing (See also 305020 for diff. units), Cut Stone: General
 30588801 Fugitive Emissions, Specify in Comments Field
 30588802 Fugitive Emissions, Specify in Comments Field
 30588803 Fugitive Emissions, Specify in Comments Field
 30588804 Fugitive Emissions, Specify in Comments Field
 30588805 Fugitive Emissions, Specify in Comments Field
 30590001 Fuel Fired Equipment, Distillate Oil (No. 2): Process Heaters
 30590003 Fuel Fired Equipment, Natural Gas: Process Heaters
 30590023 Fuel Fired Equipment, Natural Gas: Flares
 30599999 Mineral Products, Other Not Defined, Specify in Comments Field

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

AT-A-GLANCE TABLE FOR POINT SOURCES

Control Efficiency: 99% from uncontrolled for both PM10 and PM2.5

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs are generated using EPA's cost-estimating spreadsheets for fabric filters (EPA, 1998a). Costs are primarily driven by the waste stream volumetric flow rate and pollutant loading. When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan,2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 2000). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$7 to \$13 per scfm

Typical value is \$9 per scfm

O&M Costs:

Range from \$9 to \$25 per scfm

Typical value is \$14 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). O&M costs were calculated for three model plants with flow rates of 25, 75 and 150 thousand acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust loading of 4.0 grains per cubic feet. The operating time was assumed to be 8760 hours per year. An average cartridge cost was estimated using the costs for standard cartridge types. Capital recovery for the periodic replacement of cartridges was included in the O&M cost of the cartridges using a cartridge life of 2 years (EPA, 1998a). The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.0671	\$/kW-hr
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AT-A-GLANCE TABLE FOR POINT SOURCES

Compressed air	0.25	\$/1000 scf
Dust disposal	25	\$/ton disposed

Note: All costs are in 1998 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$85 to \$256 per ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$142 per ton PM10 reduced. (1998\$)

Comments:

Status: Demonstrated	Last Reviewed: 2001
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Additional Information:

Materials handling operations including crushing, grinding, and screening, can produce significant PM emissions. Drying, the heating of minerals or mineral products to remove water, and calcination, heating to higher temperatures to remove chemically bound water and other compounds, are normally performed in dedicated, closed units. Emissions from these units will be through process vents, to which PM controls can be applied relatively simply. Fugitive dust emissions may come from paved and unpaved roads in plants and from raw material and product loading, unloading, and storage (STAPPA/ALAPCO, 1996).

The cost estimates assume a conventional design under typical operating conditions. Auxiliary equipment, such as fans and ductwork, is not included (EPA, 2000). Pollutants that require an unusually high level of control or that require the filter media or the unit itself to be constructed of special materials, such as Nomex® or stainless steel, will increase the costs of the system (EPA, 1998a). The additional costs for controlling more complex waste streams are not reflected in the estimates given below. For these types of systems, the capital cost could increase by as much as 75% and the O&M cost could increase by as much as 10%. In general, a small unit controlling a low pollutant loading will not be as cost effective as a large unit controlling a high pollutant loading (EPA, 2000).

Cartridge filters contain either a paper or nonwoven fibrous filter media (EPA, 2000). Paper media is generally made of materials such as cellulose and fiberglass. The dust cake that forms on the filter media from the collected PM can significantly increase collection efficiency (EPA, 1998b).

In general, the filter media is pleated to provide a larger surface area to volume flow rate. Close pleating, however, can cause PM to bridge the pleat bottom, effectively reducing the surface collection area (EPA, 1998b). Corrugated aluminum separators are used to prevent the pleats from collapsing (Heumann, 1997). There are variety of cartridge designs and dimensions. Typical designs include flat panels, V-shaped packs or cylindrical packs (Heumann, 1997). For certain applications, two cartridges may be placed in series.

Cartridge collectors are useful for collecting particles with resistivities either too low or too high for collection with electrostatic precipitators (STAPPA/ALAPCO, 1996). For similar air flow rates, cartridge collectors are compact in size compared to traditional bag.

References:

EPA, 1998b: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, Chapter 5, EPA 453/B-96-001, Research Triangle Park, NC. December 1998.

AT-A-GLANCE TABLE FOR POINT SOURCES

EPA, 1998a: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

EPA, 2000: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Cartridge Collector with Pulse-Jet Cleaning," April 2000.

Heumann, 1997: W. L. Heumann, "Industrial Air Pollution Control Systems," McGraw Hill Publishers, Inc., Washington, D.C., 1997.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

STAPPA/ALAPCO, 1996: State and Territorial Air Pollution Program Administrators and Association of Local Air Pollution Control Officials, "Controlling Particulate Matter Under the Clean Air Act: A Menu of Options," July 1996.

STAPPA/ALAPCO, 1996: State and Territorial Air Pollution Program Administrators - Association of Local Air Pollution Control Officials, "Controlling Particulate Matter Under the Clean Air Act: A Menu of Options," Washington, DC, July 1996.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Mineral Products - Other

Control Measure Name: Fabric Filter (Reverse-Air Cleaned Type)

Rule Name: Not Applicable

Pechan Measure Code: P2216

POD: 221

Application: This control is the use of a reverse-air cleaned fabric filter to reduce PM emissions from waste streams. In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Reverse-air cleaning is performed by forcing clean air through the filters in the opposite direction of the dusty gas flow. The change in direction of the gas flow causes the bag to flex and crack the filter cake allowing for internal cake collection.

This control applies to miscellaneous mineral production operations including (but not limited to) brick manufacture, calcium carbide operations, clay and fly ash sintering, concrete batching, gypsum manufacturing, lime production, phosphate rock operations, sand production, fiberglass manufacturing and glass manufacturing operations. Materials handling operations including crushing, grinding, and screening, can produce significant PM emissions.

Affected SCC:

30500301 Mineral Products, Brick Manufacture, Raw Material Drying
30500302 Mineral Products, Brick Manufacture, Raw Material Grinding & Screening
30500303 Brick Manufacture, Storage of Raw Materials
30500305 Brick Manufacture, Raw Material Handling and Transferring
30500308 Brick Manufacture, Screening
30500309 Brick Manufacture, Blending and Mixing
30500310 Brick Manufacture, Curing and Firing: Sawdust Fired Tunnel Kilns
30500311 Mineral Products, Brick Manufacture, Curing and Firing: Gas-fired Tunnel Kilns
30500313 Mineral Products, Brick Manufacture, Curing and Firing: Coal-fired Tunnel Kilns
30500316 Brick Manufacture, Curing and Firing: Coal-fired Periodic Kilns
30500331 Brick Manufacture, Curing and Firing: Dual Fuel Fired Tunnel Kiln
30500398 Mineral Products, Brick Manufacture, Other Not Classified
30500399 Brick Manufacture, Other Not Classified
30500401 Calcium Carbide, Electric Furnace: Hoods and Main Stack
30500402 Mineral Products, Calcium Carbide, Coke Dryer
30500404 Calcium Carbide, Tap Fume Vents
30500406 Mineral Products, Calcium Carbide, Circular Charging: Conveyor
30500499 Mineral Products, Calcium Carbide, Other Not Classified
30500501 Castable Refractory, Fire Clay: Rotary Dryer
30500502 Castable Refractory, Raw Material Crushing/Processing
30500598 Castable Refractory, Other Not Classified
30500599 Castable Refractory, Other Not Classified
30500801 Ceramic Clay/Tile Manufacture, Drying ** (use SCC 3-05-008-13)
30500802 Mineral Products, Ceramic Clay/Tile, Comminution-Crushing, Grinding & Milling
30500803 Ceramic Clay/Tile Manufacture, Raw Material Storage
30500805 Ceramic Clay/Tile Manufacture, Granulation-Mixing of Ceramic Powder & Binder Sol'n
30500899 Mineral Products, Ceramic Clay/Tile Manufacture, Other Not Classified
30500901 Clay and Fly Ash Sintering, Fly Ash Sintering
30500902 Clay and Fly Ash Sintering, Clay/Coke Sintering
30500903 Clay and Fly Ash Sintering, Natural Clay/Shale Sintering

AT-A-GLANCE TABLE FOR POINT SOURCES

30500904 Clay and Fly Ash Sintering, Raw Clay/Shale Crushing/Screening
30500905 Clay and Fly Ash Sintering, Raw Clay/Shale Transfer/Conveying
30500908 Clay and Fly Ash Sintering, Sintered Clay/Shale Product Crushing/Screening
30500909 Clay and Fly Ash Sintering, Expanded Shale Clinker Cooling
30500910 Clay and Fly Ash Sintering, Expanded Shale Storage
30500915 Clay and Fly Ash Sintering, Rotary Kiln
30500999 Mineral Products, Clay and Fly Ash Sintering, Other Not Classified
30501101 Mineral Products, Concrete Batching, General (Non-fugitive)
30501106 Concrete Batching, Transfer: Sand/Aggregate to Elevated Bins
30501107 Concrete Batching, Cement Unloading: Storage Bins
30501108 Concrete Batching, Weight Hopper Loading of Cement/Sand/Aggregate
30501109 Mineral Products, Concrete Batching, Mixer Loading of Cement/Sand/Aggregate
30501110 Concrete Batching, Loading of Transit Mix Truck
30501111 Concrete Batching, Loading of Dry-batch Truck
30501112 Mineral Products, Concrete Batching, Mixing: Wet
30501113 Concrete Batching, Mixing: Dry
30501114 Concrete Batching, Transferring: Conveyors/Elevators
30501115 Concrete Batching, Storage: Bins/Hoppers
30501199 Mineral Products, Concrete Batching, Other Not Classified
30501201 Fiberglass Manufacturing, Regenerative Furnace (Wool-type Fiber)
30501203 Fiberglass Manufacturing, Electric Furnace (Wool-type Fiber)
30501204 Fiberglass Manufacturing, Forming: Rotary Spun (Wool-type Fiber)
30501205 Fiberglass Manufacturing, Curing Oven: Rotary Spun (Wool-type Fiber)
30501206 Fiberglass Manufacturing, Cooling (Wool-type Fiber)
30501207 Fiberglass Manufacturing, Unit Melter Furnace (Wool-type Fiber)
30501208 Fiberglass Manufacturing, Forming: Flame Attenuation (Wool-type Fiber)
30501209 Fiberglass Manufacturing, Curing: Flame Attenuation (Wool-type Fiber)
30501211 Fiberglass Manufacturing, Regenerative Furnace (Textile-type Fiber)
30501212 Fiberglass Manufacturing, Recuperative Furnace (Textile-type Fiber)
30501213 Fiberglass Manufacturing, Unit Melter Furnace (Textile-type Fiber)
30501214 Fiberglass Manufacturing, Forming Process (Textile-type Fiber)
30501215 Fiberglass Manufacturing, Curing Oven (Textile-type Fiber)
30501221 Fiberglass Manufacturing, Raw Material: Unloading/Conveying
30501223 Fiberglass Manufacturing, Raw Material: Mixing/Weighing
30501299 Mineral Products, Fiberglass Manufacturing, Other Not Classified
30501401 Glass Manufacture, Furnace/General**
30501402 Mineral Products, Glass Manufacture, Container Glass: Melting Furnace
30501403 Mineral Products, Glass Manufacture, Flat Glass: Melting Furnace
30501404 Glass Manufacture, Pressed and Blown Glass: Melting Furnace
30501406 Mineral Products, Glass Manufacture, Container Glass: Forming/Finishing
30501407 Glass Manufacture, Flat Glass: Forming/Finishing
30501408 Glass Manufacture, Pressed and Blown Glass: Forming/Finishing
30501410 Glass Manufacture, Raw Material Handling (All Types of Glass)
30501411 Glass Manufacture, General **
30501413 Mineral Products, Glass Manufacture, Cullet: Crushing/Grinding
30501415 Mineral Products, Glass Manufacture, Glass Etching with Hydrofluoric Acid Solution
30501416 Glass Manufacture, Glass Manufacturing
30501499 Glass Manufacture, See Comment **
30501501 Mineral Products, Gypsum Manufacture, Rotary Ore Dryer
30501502 Mineral Products, Gypsum Manufacture, Primary Grinder/Roller Mills
30501503 Gypsum Manufacture, Not Classified **
30501504 Mineral Products, Gypsum Manufacture, Conveying

AT-A-GLANCE TABLE FOR POINT SOURCES

30501505 Gypsum Manufacture, Primary Crushing: Gypsum Ore
30501506 Gypsum Manufacture, Secondary Crushing: Gypsum Ore
30501507 Gypsum Manufacture, Screening: Gypsum Ore
30501508 Mineral Products, Gypsum Manufacture, Stockpile: Gypsum Ore
30501509 Mineral Products, Gypsum Manufacture, Storage Bins: Gypsum Ore
30501511 Gypsum Manufacture, Continuous Kettle: Calciner
30501512 Gypsum Manufacture, Flash Calciner
30501513 Gypsum Manufacture, Impact Mill
30501514 Gypsum Manufacture, Storage Bins: Stucco
30501515 Gypsum Manufacture, Tube/Ball Mills
30501516 Gypsum Manufacture, Mixers
30501518 Mineral Products, Gypsum Manufacture, Mixers/Conveyors
30501519 Gypsum Manufacture, Forming Line
30501520 Mineral Products, Gypsum Manufacture, Drying Kiln
30501521 Mineral Products, Gypsum Manufacture, End Sawing (8 Ft.)
30501522 Mineral Products, Gypsum Manufacture, End Sawing (12 Ft.)
30501601 Lime Manufacture, Primary Crushing
30501602 Lime Manufacture, Secondary Crushing/Screening
30501603 Mineral Products, Lime Manufacture, Calcining: Vertical Kiln
30501604 Mineral Products, Lime Manufacture, Calcining: Rotary Kiln ** (See SCC Codes 3-05-016-18,-19,-20,-21)
30501605 Mineral Products, Lime Manufacture, Calcining: Gas-fired Calcimatic Kiln
30501606 Lime Manufacture, Fluidized Bed Kiln
30501607 Lime Manufacture, Raw Material Transfer and Conveying
30501608 Lime Manufacture, Raw Material Unloading
30501609 Lime Manufacture, Hydrator: Atmospheric
30501610 Lime Manufacture, Raw Material Storage Piles
30501611 Lime Manufacture, Product Cooler
30501612 Lime Manufacture, Pressure Hydrator
30501613 Mineral Products, Lime Manufacture, Lime Silos
30501614 Lime Manufacture, Packing/Shipping
30501615 Lime Manufacture, Product Transfer and Conveying
30501616 Lime Manufacture, Primary Screening
30501617 Lime Manufacture, Multiple Hearth Calciner
30501619 Lime Manufacture, Calcining: Gas-fired Rotary Kiln
30501620 Lime Manufacture, Calcining: Coal- and Gas-fired Rotary Kiln
30501626 Lime Manufacture, Product Loading, Enclosed Truck
30501640 Lime Manufacture, Vehicle Traffic
30501699 Lime Manufacture, See Comment **
30501701 Mineral Wool, Cupola
30501703 Mineral Wool, Blow Chamber
30501704 Mineral Wool, Curing Oven
30501705 Mineral Wool, Cooler
30501799 Mineral Wool, Other Not Classified
30501801 Perlite Manufacturing, Vertical Furnace
30501899 Perlite Manufacturing, Other Not Classified
30501901 Phosphate Rock, Drying
30501902 Phosphate Rock, Grinding
30501903 Phosphate Rock, Transfer/Storage
30501905 Mineral Products, Phosphate Rock, Calcining
30501906 Phosphate Rock, Rotary Dryer
30501907 Phosphate Rock, Ball Mill

AT-A-GLANCE TABLE FOR POINT SOURCES

30501999 Phosphate Rock, Other Not Classified
30502101 Salt Mining, General
30502201 Potash Production, Mine: Grinding/Drying
30502299 Potash Production, Other Not Classified
30502401 Magnesium Carbonate, Mine/Process
30502501 Construction Sand and Gravel, Total Plant: General **
30502502 Construction Sand and Gravel, Aggregate Storage
30502503 Construction Sand and Gravel, Material Transfer and Conveying
30502504 Construction Sand and Gravel, Hauling
30502505 Construction Sand and Gravel, Pile Forming: Stacker
30502506 Construction Sand and Gravel, Bulk Loading
30502507 Construction Sand and Gravel, Storage Piles
30502508 Construction Sand & Gravel, Dryer (See 305027-20 thru -24 for Industrial Sand Dryers)
30502509 Construction Sand and Gravel, Cooler ** (See 3-05-027-30 for Industrial Sand Coolers)
30502510 Mineral Products, Construction Sand and Gravel, Crushing
30502511 Construction Sand and Gravel, Screening
30502599 Construction Sand and Gravel, Not Classified **
30502601 Diatomaceous Earth, Handling
30502699 Diatomaceous Earth, Other Not Classified
30502701 Industrial Sand and Gravel, Primary Crushing of Raw Material
30502705 Industrial Sand and Gravel, Secondary Crushing
30502709 Industrial Sand and Gravel, Grinding: Size Reduction to 50 Microns or Smaller
30502713 Industrial Sand and Gravel, Screening: Size Classification
30502760 Industrial Sand and Gravel, Sand Handling, Transfer, and Storage
30503099 Ceramic Electric Parts, Other Not Classified
30503301 Vermiculite, General
30504001 Mining and Quarrying of Nonmetallic Minerals, Open Pit Blasting
30504002 Mining and Quarrying of Nonmetallic Minerals, Open Pit Drilling
30504003 Mining and Quarrying of Nonmetallic Minerals, Open Pit Cobbing
30504010 Mining and Quarrying of Nonmetallic Minerals, Underground Ventilation
30504020 Mining and Quarrying of Nonmetallic Minerals, Loading
30504021 Mineral Products, Mining and Quarrying of Nonmetallic Minerals, Convey/Haul Material
30504022 Mining and Quarrying of Nonmetallic Minerals, Convey/Haul Waste
30504023 Mining and Quarrying of Nonmetallic Minerals, Unloading
30504024 Mining and Quarrying of Nonmetallic Minerals, Overburden Stripping
30504025 Mining and Quarrying of Nonmetallic Minerals, Stockpiling
30504030 Mineral Products, Mining and Quarrying of Nonmetallic Minerals, Primary Crusher
30504031 Mineral Products, Mining and Quarrying of Nonmetallic Minerals, Secondary Crusher
30504033 Mining and Quarrying of Nonmetallic Minerals, Ore Dryer
30504034 Mining and Quarrying of Nonmetallic Minerals, Screening
30504036 Mining and Quarrying of Nonmetallic Minerals, Tailing Piles
30504099 Mining and Quarrying of Nonmetallic Minerals, Other Not Classified
30504140 Clay processing: Kaolin, Calcining, rotary calciner
30510001 Bulk Materials Elevators, Unloading
30510002 Bulk Materials Elevators, Loading
30510101 Bulk Materials Conveyors, Ammonium Sulfate
30510103 Bulk Materials Conveyors, Coal
30510104 Bulk Materials Conveyors, Coke
30510105 Bulk Materials Conveyors, Limestone
30510197 Bulk Materials Conveyors, Fertilizer: Specify in Comments
30510198 Bulk Materials Conveyors, Mineral: Specify in Comments
30510199 Bulk Materials Conveyors, Other Not Classified

AT-A-GLANCE TABLE FOR POINT SOURCES

30510202 Mineral Products, Bulk Materials Storage Bins, Cement
30510203 Bulk Materials Storage Bins, Coal
30510204 Bulk Materials Storage Bins, Coke
30510205 Bulk Materials Storage Bins, Limestone
30510298 Mineral Products, Bulk Materials Storage Bins, Mineral: Specify in Comments
30510299 Bulk Materials Storage Bins, Other Not Classified
30510303 Bulk Materials Open Stockpiles, Coal
30510304 Bulk Materials Open Stockpiles, Coke
30510397 Bulk Materials Open Stockpiles, Fertilizer: Specify in Comments
30510398 Bulk Materials Open Stockpiles, Mineral: Specify in Comments
30510399 Bulk Materials Open Stockpiles, Other Not Classified
30510402 Bulk Materials Unloading Operation, Cement
30510403 Mineral Products, Bulk Materials Unloading Operation, Coal
30510404 Bulk Materials Unloading Operation, Coke
30510405 Bulk Materials Unloading Operation, Limestone
30510406 Bulk Materials Unloading Operation, Phosphate Rock
30510407 Bulk Materials Unloading Operation, Scrap Metal
30510497 Bulk Materials Unloading Operation, Fertilizer: Specify in Comments
30510498 Bulk Materials Unloading Operation, Mineral: Specify in Comments
30510499 Bulk Materials Unloading Operation, Other Not Classified
30510503 Bulk Materials Loading Operation, Coal
30510505 Bulk Materials Loading Operation, Limestone
30510507 Bulk Materials Loading Operation, Scrap Metal
30510596 Bulk Materials Loading Operation, Chemical: Specify in Comments
30510597 Bulk Materials Loading Operation, Fertilizer: Specify in Comments
30510598 Bulk Materials Loading Operation, Mineral: Specify in Comments
30510599 Bulk Materials Loading Operation, Other Not Classified
30515001 Calcining, Raw Material Handling
30515002 Calcining, General
30515004 Calcining, Finished Product Handling
30531008 Coal Mining, Cleaning, and Material Handling (See 305010), Unloading
30531009 Coal Mining, Cleaning, and Material Handling (See 305010), Raw Coal Storage
30531010 Coal Mining, Cleaning, and Material Handling (See 305010), Crushing
30531011 Coal Mining, Cleaning, and Material Handling (See 305010), Coal Transfer
30531012 Coal Mining, Cleaning, and Material Handling (See 305010), Screening
30531014 Coal Mining, Cleaning, and Material Handling (See 305010), Cleaned Coal Storage
30531090 Coal Mining, Cleaning, and Material Handling (See 305010), Haul Roads: General
30531099 Coal Mining, Cleaning, and Material Handling (See 305010), Other Not Classified
30532006 Stone Quarrying-Processing (See 305020), Misc. Operations
30532008 Stone Quarrying - Processing (See also 305020 for diff. units), Cut Stone: General
30588801 Fugitive Emissions, Specify in Comments Field
30588802 Fugitive Emissions, Specify in Comments Field
30588803 Fugitive Emissions, Specify in Comments Field
30588804 Fugitive Emissions, Specify in Comments Field
30588805 Fugitive Emissions, Specify in Comments Field
30590001 Fuel Fired Equipment, Distillate Oil (No. 2): Process Heaters
30590003 Fuel Fired Equipment, Natural Gas: Process Heaters
30590023 Fuel Fired Equipment, Natural Gas: Flares
30599999 Mineral Products, Other Not Defined, Specify in Comments Field

AT-A-GLANCE TABLE FOR POINT SOURCES

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 99% from uncontrolled for both PM10 and PM2.5

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs for reverse-air cleaned systems are generated using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan,2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 2000). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$9 to \$84 per scfm

Typical value is \$34 per scfm

O&M Costs:

Range from \$6 to \$27 per scfm

Typical value is \$13 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). O&M costs were calculated for three model plants with flow rates of 25, 75 and 150 thousand acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust loading of 4.0 grains per cubic feet. The operating time was assumed to be 8760 hours per year. An average bag cost was estimated using the costs for standard bag

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types. Capital recovery for the periodic replacement of bags was included in the O&M cost of the bags using a bag life of 2 years (EPA, 1998a). The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.0671	\$/kW-hr
Compressed air	0.25	\$/1000 scf
Dust disposal	25	\$/ton disposed

Note: All costs are in 1998 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$53 to \$337 per ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$148 per ton PM10 reduced. (1998\$)

Comments:

Status: Demonstrated	Last Reviewed: 2001
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Additional Information:

Materials handling operations including crushing, grinding, and screening, can produce significant PM emissions. Drying, the heating of minerals or mineral products to remove water, and calcination, heating to higher temperatures to remove chemically bound water and other compounds, are normally performed in dedicated, closed units. Emissions from these units will be through process vents, to which PM controls can be applied relatively simply. Fugitive dust emissions may come from paved and unpaved roads in plants and from raw material and product loading, unloading, and storage (STAPPA/ALAPCO, 1996).

The cost estimates assume a conventional design under typical operating conditions. The costs do not include any auxiliary equipment (EPA, 2000).

The capital cost for the reverse-jet cleaned fabric baghouse is based on information provided by a manufacturer (EPA, 2000). The capital cost includes only the purchased equipment cost.

Costs are primarily based on volumetric flow rate and the amount of PM in the waste stream. In general, a small unit controlling a low pollutant levels will not be as cost effective as a large unit controlling a high pollutant levels. (EPA, 2000)

Pollutants requiring a high level of control or the fabric filters to be constructed of special materials will increase the costs of the system (EPA, 1998a). The additional costs for controlling complex streams are not reflected in the estimates. For these systems, the capital cost could increase by as much as 40% and the O&M cost could increase by as much as 5%. (EPA, 2000)

In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Fabric filters may be in the form of sheets, cartridges, or bags, with many individual filter units together in a group. Bags are the most common type of filter. The dust cake that forms on the filter from the collected PM can significantly increase collection efficiency. (EPA, 2000)

Reverse-air cleaning is a popular filter cleaning method as it has been used extensively and improved over the years. It is a gentler but sometimes less effective clearing mechanism than mechanical shaking. Reverse-air cleaning is performed by forcing clean air through the filters in the opposite direction of the dusty gas flow. The change in direction of the gas flow causes the bag to

AT-A-GLANCE TABLE FOR POINT SOURCES

flex and crack the filter cake allowing for internal cake collection (EPA, 2000).

The most common design is to have separate compartments within the fabric filter so that each can be isolated and cleaned separately while the others continue to treat the dusty gas. There are several methods of reversing the flow through the filters. One method of providing the reverse flow is by the use of a fan or cleaned gas from other compartments. Reverse-air cleaning only used alone in cases where the dust releases easily from the fabric. In many instances, reverse-air is used along with shaking, pulsing or sonic horns (EPA, 1998b).

Fabric filters are useful for collecting particles with resistivities either too low or too high for collection with electrostatic precipitators. Fabric filters are useful in controlling particulate matter less than or equal to 10 micrometers (μm) in diameter (PM₁₀) and particulate matter less than or equal to 2.5 μm in diameter (PM_{2.5}). Fabric filters may be good candidates for collecting fly ash from low-sulfur coals or containing high unburned carbon levels and are relatively difficult to collect with electrostatic precipitators. (EPA, 2000)

References:

EPA, 1998b: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

EPA, 1998a: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, Chapter 5, EPA 453/B-96-001, Research Triangle Park, NC. December 1998.

EPA, 2000: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Fabric Filter - Reverse-Air Cleaned Type," April 2000.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

STAPPA/ALAPCO, 1996: State and Territorial Air Pollution Program Administrators - Association of Local Air Pollution Control Officials, Controlling Particulate Matter Under the Clean Air Act: A Menu of Options, Washington, DC, July 1996.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Mineral Products - Other

Control Measure Name: Increased Monitoring Frequency (IMF) of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P3221

POD: 221

Application: This measure is to conduct improved monitoring for PM_{2.5} emissions at stationary sources. Improved monitoring in this case means increasing the monitoring frequency of electrostatic precipitators, scrubbers, and fabric filters from once per day to four times per hour, with no change in monitoring technique.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (Barr and Schaffner) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

305004** Mineral Products, Calcium Carbide
305003** Mineral Products, Brick Manufacture
305092** Mineral Products, Catalyst Manufacturing
305100** Mineral Products, Bulk Materials Elevators
305101** Mineral Products, Bulk Materials Conveyors
305102** Mineral Products, Bulk Materials Storage Bins
305104** Mineral Products, Bulk Materials Unloading Operation
305005** Mineral Products, Castable Refractory
305900** Mineral Products, Fuel Fired Equipment
305888** Mineral Products, Fugitive Emissions
305105** Mineral Products, Bulk Materials Loading Operation
305106** Mineral Products, Bulk Materials Screening/Size Classification
305999** Mineral Products, Other Not Defined
305108** Mineral Products, Bulk Materials: Grinding/Crushing
305150** Mineral Products, Calcining
305310** Mineral Products, Coal Mining, Cleaning, and Material Handling
305320** Mineral Products, Stone Quarrying - Processing
305090** Mineral Products, Mica
305103** Mineral Products, Bulk Materials Open Stockpiles
305040** Mineral Products, Mining and Quarrying of Nonmetallic Minerals
305022** Mineral Products, Potash Production
305025** Mineral Products, Construction Sand and Gravel
305026** Mineral Products, Diatomaceous Earth
305027** Mineral Products, Industrial Sand and Gravel
305033** Mineral Products, Vermiculite
305021** Mineral Products, Salt Mining

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305036** Mineral Products, Bonded Abrasives Manufacturing
 305030** Mineral Products, Ceramic Electric Parts
 305008** Mineral Products, Ceramic Clay/Tile Manufacture
 305041** Mineral Products, Clay processing: Kaolin
 305042** Mineral Products, Clay processing: Ball clay
 305044** Mineral Products, Clay processing: Bentonite
 305089** Mineral Products, Talc Processing
 305050** Mineral Products, Asphalt Processing (Blowing)
 305034** Mineral Products, Feldspar
 305017** Mineral Products, Mineral Wool
 305015** Mineral Products, Gypsum Manufacture
 305016** Mineral Products, Lime Manufacture
 305014** Mineral Products, Glass Manufacture
 305018** Mineral Products, Perlite Manufacturing
 305013** Mineral Products, Frit Manufacture
 305012** Mineral Products, Fiberglass Manufacturing
 305011** Mineral Products, Concrete Batching
 305019** Mineral Products, Phosphate Rock
 305009** Mineral Products, Clay and Fly Ash Sintering

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 6.5% for both PM10 and PM2.5

Equipment Life: Not applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs included the incremental record keeping and reporting associated with the increased monitoring frequency. Labor rates for 2003 were made that were obtained from the Bureau of Labor Statistics (labor rates include 140 percent overhead). The incremental costs included a one-time cost for development of the improved monitoring and recurring annual burden costs for incremental record keeping, reporting, and certification activities.

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$620 per ton PM reduced (2003\$).

Comments:

Status:	Last Reviewed: 2004
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Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM2.5 Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 2003.

BLS, 2003: Bureau of Labor Statistics, "Employer Costs for Employee Compensation – June 2003," Table 12, page 16, 2003.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Mineral Products - Other

Control Measure Name: CEM Upgrade and Increased Monitoring Frequency of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P4221

POD: 221

Application: This measure examines the impacts of improving the PM monitoring technique at units currently using an ESP, scrubber, or fabric filter. In this improved technique scenario, the monitoring technique is upgraded to a PM continuous emission monitor. This improved monitoring technique also results in an increase to the monitoring frequency because a PM CEMS can make a measurement every 7.5 minutes. The monitoring frequency increases from once per day to eight times per hour.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (see References) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

305004** Mineral Products, Calcium Carbide
305003** Mineral Products, Brick Manufacture
305092** Mineral Products, Catalyst Manufacturing
305100** Mineral Products, Bulk Materials Elevators
305101** Mineral Products, Bulk Materials Conveyors
305102** Mineral Products, Bulk Materials Storage Bins
305104** Mineral Products, Bulk Materials Unloading Operation
305005** Mineral Products, Castable Refractory
305900** Mineral Products, Fuel Fired Equipment
305888** Mineral Products, Fugitive Emissions
305105** Mineral Products, Bulk Materials Loading Operation
305106** Mineral Products, Bulk Materials Screening/Size Classification
305999** Mineral Products, Other Not Defined
305108** Mineral Products, Bulk Materials: Grinding/Crushing
305150** Mineral Products, Calcining
305310** Mineral Products, Coal Mining, Cleaning, and Material Handling
305320** Mineral Products, Stone Quarrying - Processing
305090** Mineral Products, Mica
305103** Mineral Products, Bulk Materials Open Stockpiles
305040** Mineral Products, Mining and Quarrying of Nonmetallic Minerals
305022** Mineral Products, Potash Production
305025** Mineral Products, Construction Sand and Gravel
305026** Mineral Products, Diatomaceous Earth
305027** Mineral Products, Industrial Sand and Gravel

AT-A-GLANCE TABLE FOR POINT SOURCES

305033** Mineral Products, Vermiculite
305021** Mineral Products, Salt Mining
305036** Mineral Products, Bonded Abrasives Manufacturing
305030** Mineral Products, Ceramic Electric Parts
305008** Mineral Products, Ceramic Clay/Tile Manufacture
305041** Mineral Products, Clay processing: Kaolin
305042** Mineral Products, Clay processing: Ball clay
305044** Mineral Products, Clay processing: Bentonite
305089** Mineral Products, Talc Processing
305050** Mineral Products, Asphalt Processing (Blowing)
305034** Mineral Products, Feldspar
305017** Mineral Products, Mineral Wool
305015** Mineral Products, Gypsum Manufacture
305016** Mineral Products, Lime Manufacture
305014** Mineral Products, Glass Manufacture
305018** Mineral Products, Perlite Manufacturing
305013** Mineral Products, Frit Manufacture
305012** Mineral Products, Fiberglass Manufacturing
305011** Mineral Products, Concrete Batching
305019** Mineral Products, Phosphate Rock
305009** Mineral Products, Clay and Fly Ash Sintering

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 7.7% for both PM10 and PM2.5

Equipment Life: Unknown

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The total capital and annual operating costs for implementing an improved monitoring technique are calculated based on data from the EPA CEMS Cost Model and the PM CEMS Knowledge document. Labor rates in the EPA CEMS Cost Model are scaled to reflect 2003 labor rates (including 140 percent overhead) provided by the Bureau of Labor Statistics.

The cost effectiveness at a percent excess emission rate of 0.46 percent is \$5,200 per ton of PM2.5. This is based on a \$34 million capital investment cost, and a \$14 million total annualized cost when applied to 128 facilities.

Note: All costs are in 2003 dollars.

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$5,200 per ton PM reduced (2003\$).

Comments:

Status: **Last Reviewed:** 2004

Additional Information:

AT-A-GLANCE TABLE FOR POINT SOURCES

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM2.5 Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 8, 2003.

EPA CEMS Cost Model, Version 3.0, U.S. Environmental Protection Agency.

EPA, 2000: U.S. Environmental Protection Agency, "Current Knowledge of Particulate Matter (PM) Continuous Emissions Monitoring," Chapter 9, PM CEMS Cost, September 8, 2000.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Mineral Products - Stone Quarrying & Processing

Control Measure Name: Increased Monitoring Frequency (IMF) of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P3220

POD: 220

Application: This measure is to conduct improved monitoring for PM_{2.5} emissions at stationary sources. Improved monitoring in this case means increasing the monitoring frequency of electrostatic precipitators, scrubbers, and fabric filters from once per day to four times per hour, with no change in monitoring technique.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (Barr and Schaffner) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

305020** Mineral Products, Stone Quarrying - Processing

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 6.5% for both PM₁₀ and PM_{2.5}

Equipment Life: Not applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs included the incremental record keeping and reporting associated with the increased monitoring frequency. Labor rates for 2003 were made that were obtained from the Bureau of Labor Statistics (labor rates include 140 percent overhead). The incremental costs included a one-time cost for development of the improved monitoring and recurring annual burden costs for incremental record keeping, reporting, and certification activities.

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$620 per ton PM reduced (2003\$).

Comments:

Status:

Last Reviewed: 2004

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM2.5 Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 2003.

BLS, 2003: Bureau of Labor Statistics, "Employer Costs for Employee Compensation – June 2003," Table 12, page 16, 2003.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Mineral Products - Stone Quarrying & Processing

Control Measure Name: CEM Upgrade and Increased Monitoring Frequency of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P4220

POD: 220

Application: This measure examines the impacts of improving the PM monitoring technique at units currently using an ESP, scrubber, or fabric filter. In this improved technique scenario, the monitoring technique is upgraded to a PM continuous emission monitor. This improved monitoring technique also results in an increase to the monitoring frequency because a PM CEMS can make a measurement every 7.5 minutes. The monitoring frequency increases from once per day to eight times per hour.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (see References) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

305020** Mineral Products, Stone Quarrying - Processing

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 7.7% for both PM10 and PM2.5

Equipment Life: Unknown

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The total capital and annual operating costs for implementing an improved monitoring technique are calculated based on data from the EPA CEMS Cost Model and the PM CEMS Knowledge document. Labor rates in the EPA CEMS Cost Model are scaled to reflect 2003 labor rates (including 140 percent overhead) provided by the Bureau of Labor Statistics.

The cost effectiveness at a percent excess emission rate of 0.46 percent is \$5,200 per ton of PM2.5. This is based on a \$34 million capital investment cost, and a \$14 million total annualized cost when applied to 128 facilities.

Note: All costs are in 2003 dollars.

AT-A-GLANCE TABLE FOR POINT SOURCES

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$5,200 per ton PM reduced (2003\$).

Comments:

Status:

Last Reviewed: 2004

Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM_{2.5} Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 8, 2003.

EPA CEMS Cost Model, Version 3.0, U.S. Environmental Protection Agency.

EPA, 2000: U.S. Environmental Protection Agency, "Current Knowledge of Particulate Matter (PM) Continuous Emissions Monitoring," Chapter 9, PM CEMS Cost, September 8, 2000.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Mineral Products - Stone Quarrying and Processing

Control Measure Name: Fabric Filter (Pulse Jet Type)

Rule Name: Not Applicable

Pechan Measure Code: P2201

POD: 220

Application: This control is the addition of a pulse-jet cleaned fabric filter to reduce PM emissions from waste streams. In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Particulate-laden gas flows into the filter bag from the outside to the inside. The particles collected on the outside drop into a hopper below the fabric filter. During pulse-jet cleaning, a short burst of high pressure air is injected into the bags, dislodging the dust cake.

This control applies to stone quarrying and processing operations. Nonmetallic Mineral Processing (305020) - ore crushing, grinding, and screening, and Calciners (SCC 305150) and Dryers (SCC 30502012) are considered in this category, among others. Materials handling operations including crushing, grinding, and screening, can produce significant PM emissions.

Affected SCC:

30502001 Mineral Products, Stone Quarrying - Processing (See also 305320), Primary Crushing
30502002 Mineral Products, Stone Quarrying-Processing, Secondary Crushing/Screening
30502003 Mineral Products, Stone Quarrying-Processing, Tertiary Crushing/Screening
30502004 Stone Quarrying - Processing (See also 305320), Recrushing/Screening
30502005 Stone Quarrying - Processing (See also 305320), Fines Mill
30502006 Mineral Products, Stone Quarrying-Processing (See 305320), Misc. Operations
30502007 Stone Quarrying - Processing (See also 305320), Open Storage
30502008 Stone Quarrying - Processing (See also 305320), Cut Stone: General
30502009 Stone Quarrying - Processing (See also 305320), Blasting: General
30502010 Stone Quarrying - Processing (See also 305320), Drilling
30502011 Stone Quarrying - Processing (See also 305320), Hauling
30502012 Mineral Products, Stone Quarrying - Processing (See also 305320), Drying
30502013 Stone Quarrying - Processing (See also 305320), Bar Grizzlies
30502014 Stone Quarrying - Processing (See also 305320), Shaker Screens
30502015 Stone Quarrying - Processing (See also 305320), Vibrating Screens
30502017 Stone Quarrying - Processing (See also 305320), Pugmill
30502020 Stone Quarrying - Processing (See also 305320), Drilling
30502031 Stone Quarrying - Processing (See also 305320), Truck Unloading
30502033 Stone Quarrying - Processing (See also 305320), Truck Loading: Front End Loader
30502099 Stone Quarrying - Processing (See also 305320), Not Classified **

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 99% from uncontrolled for both PM10 and PM2.5

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

AT-A-GLANCE TABLE FOR POINT SOURCES

Cost Basis: The costs for pulse-jet cleaned systems are generated using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM₁₀ removed were used (Pechan, 2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 2000). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$6 to \$26 per scfm

Typical value is \$13 per scfm

O&M Costs:

Range from \$5 to \$24 per scfm

Typical value is \$11 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). O&M costs were calculated for three model plants with flow rates of 25, 75 and 150 thousand acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust loading of 4.0 grains per cubic feet. The operating time was assumed to be 8760 hours per year. An average bag cost was estimated using the costs for standard bag types. Capital recovery for the periodic replacement of bags was included in the O&M cost of the bags using a bag life of 2 years (EPA, 1998a). The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.0671	\$/kW-hr
Compressed air	0.25	\$/1000 scf
Dust disposal	25	\$/ton disposed

Note: All costs are in 1998 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$42 to \$266 per

AT-A-GLANCE TABLE FOR POINT SOURCES

ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$117 per ton PM10 reduced. (1998\$)

Comments:

Status: Demonstrated**Last Reviewed:** 2001

Additional Information:

Drying, the heating of minerals or mineral products to remove water, and calcination, heating to higher temperatures to remove chemically bound water and other compounds, are normally performed in dedicated, closed units. Emissions from these units will be through process vents, to which PM controls can be applied relatively simply. Fugitive dust emissions may come from paved and unpaved roads in plants and from raw material and product loading, unloading, and storage (STAPPA/ALAPCO, 1996).

The cost estimates assume a conventional design under typical operating conditions and do not include auxiliary equipment such as fans and ductwork. The costs for pulse-jet cleaned systems are generated using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a).

Costs are primarily based on volumetric flow rate and the amount of PM in the waste stream. In general, a small unit controlling a low pollutant levels will not be as cost effective as a large unit controlling a high pollutant levels. (EPA, 2000)

Pollutants requiring a high level of control or the fabric filters to be constructed of special materials will increase the costs of the system (EPA, 1998a). The additional costs for controlling complex waste streams are not included in the estimates. For these systems, the capital cost could increase by as much as 75% and the operational and maintenance (O&M) cost could increase by as much as 20% (EPA, 2000).

In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Fabric filters may be in the form of sheets, cartridges, or bags, with many individual filter units together in a group. Bags are the most common type of filter. The dust cake that forms on the filter from the collected PM can significantly increase collection efficiency. (EPA, 2000)

Pulse-jet cleaning of fabric filters is a relatively new type of fabric filter, as they have only been used for the past 30 years. This cleaning mechanism has grown in popularity because it can treat high dust loadings, operate at constant pressure drop, and occupy less space than other types of fabric filters (EPA, 2000). Particulate-laden gas flows into the bag. The gas flows from the outside to the inside of the bags, and then out the gas exhaust. The particles collected on the outside drop into a hopper below the fabric filter (EPA, 1998b).

During pulse-jet cleaning, a short burst of high pressure air is injected into the bags (EPA, 1998b). The pulse is blown through a venturi nozzle at the top of the bags and establishes a shock wave that continues onto the bottom of the bag. The wave flexes the fabric dislodging the dust cake.

There are several unique attributes of pulse-jet cleaning. The cleaning pulse is very brief allowing the flow of dusty gas to continue during cleaning. The bags not being cleaned continue to filter, taking on extra duty from the bags being cleaned (EPA, 2000). Pulse-jet cleaning is more intense and occurs with greater frequency than the other fabric filter cleaning methods. The cleaning dislodges nearly all of the dust cake each time the bag is pulsed. Pulse-jet filters, as a result, do not rely on a dust cake to provide filtration. Felted (non-woven) fabrics are used in these types of filters

AT-A-GLANCE TABLE FOR POINT SOURCES

because they do not require a dust cake. Also it has been found that woven fabrics used with pulse-jet cleaning leak dust after they are cleaned (EPA, 1998b).

Since bags cleaned by the pulse-jet method do not need to be isolated for cleaning, pulsejet cleaned fabric filters do not need extra compartments to maintain adequate filtration during cleaning. Also, because of the intense and frequent nature of the cleaning, they can treat higher gas flow rates with higher dust loadings. Consequently, fabric filters cleaned by the pulse-jet method can be smaller than other filters in the treatment of the same amount of gas and dust, making higher gas-to-cloth ratios achievable (EPA, 1998b).

Fabric filters are useful for collecting particles with resistivities either too low or too high for collection with electrostatic precipitators. Fabric filters are useful in controlling particulate matter less than or equal to 10 micrometers (μm) in diameter (PM10) and particulate matter less than or equal to 2.5 μm in diameter (PM2.5). Fabric filters may be good candidates for collecting fly ash from low-sulfur coals or containing high unburned carbon levels and are relatively difficult to collect with electrostatic precipitators. (EPA, 2000)

References:

EPA, 1998a: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, Chapter 5, EPA 453/B-96-001, Research Triangle Park, NC. December 1998.

EPA, 1998b: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

EPA, 2000: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Fabric Filter - Pulse-Jet Cleaned Type," April 2000.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

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AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Mineral Products - Stone Quarrying and Processing

Control Measure Name: Fabric Filter (Mech. Shaker Type)

Rule Name: Not Applicable

Pechan Measure Code: P2202

POD: 220

Application: This control is the addition of a mechanical shaker type fabric filter to reduce PM emissions. In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. The gas stream is drawn from beneath a cell plate in the floor and into the filter bags. The gas proceeds from the inside to the outside of the filter bags. The particles collect on the inside of the bags, forming a filter cake. In mechanical shaking units, the tops of bags are attached to a shaker bar, moved briskly to clean the bags.

This control applies to stone quarrying and processing operations. Nonmetallic Mineral Processing (305020) - ore crushing, grinding, and screening, and Calciners (SCC 305150) and Dryers (SCC 30502012), among others, are considered in this category.

Affected SCC:

30502001 Mineral Products, Stone Quarrying - Processing (See also 305320), Primary Crushing
30502002 Mineral Products, Stone Quarrying-Processing, Secondary Crushing/Screening
30502003 Mineral Products, Stone Quarrying-Processing, Tertiary Crushing/Screening
30502004 Stone Quarrying - Processing (See also 305320), Recrushing/Screening
30502005 Stone Quarrying - Processing (See also 305320), Fines Mill
30502006 Mineral Products, Stone Quarrying-Processing (See 305320), Misc. Operations
30502007 Stone Quarrying - Processing (See also 305320), Open Storage
30502008 Stone Quarrying - Processing (See also 305320), Cut Stone: General
30502009 Stone Quarrying - Processing (See also 305320), Blasting: General
30502010 Stone Quarrying - Processing (See also 305320), Drilling
30502011 Stone Quarrying - Processing (See also 305320), Hauling
30502012 Mineral Products, Stone Quarrying - Processing (See also 305320), Drying
30502013 Stone Quarrying - Processing (See also 305320), Bar Grizzlies
30502014 Stone Quarrying - Processing (See also 305320), Shaker Screens
30502015 Stone Quarrying - Processing (See also 305320), Vibrating Screens
30502017 Stone Quarrying - Processing (See also 305320), Pugmill
30502020 Stone Quarrying - Processing (See also 305320), Drilling
30502031 Stone Quarrying - Processing (See also 305320), Truck Unloading
30502033 Stone Quarrying - Processing (See also 305320), Truck Loading: Front End Loader
30502099 Stone Quarrying - Processing (See also 305320), Not Classified **

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 99% from uncontrolled for both PM10 and PM2.5

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

AT-A-GLANCE TABLE FOR POINT SOURCES

Cost Basis: The costs for mechanical shaker cleaned systems are generated using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM₁₀ removed were used (Pechan, 2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 2000). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$8 to \$71 per scfm

Typical value is \$29 per scfm

O&M Costs:

Range from \$4 to \$24 per scfm

Typical value is \$11 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). O&M costs were calculated for three model plants with flow rates of 25, 75 and 150 thousand acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust loading of 4.0 grains per cubic feet. The operating time was assumed to be 8760 hours per year. An average bag cost was estimated using the costs for standard bag types. Capital recovery for the periodic replacement of bags was included in the O&M cost of the bags using a bag life of 2 years (EPA, 1998a). The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.0671	\$/kW-hr
Compressed air	0.25	\$/1000 scf
Dust disposal	25	\$/ton disposed

Note: All costs are in 1998 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$37 to \$303 per

AT-A-GLANCE TABLE FOR POINT SOURCES

ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$126 per ton PM10 reduced. (1998\$)

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

Materials handling operations including crushing, grinding, and screening, can produce significant PM emissions. Drying, the heating of minerals or mineral products to remove water, and calcination, heating to higher temperatures to remove chemically bound water and other compounds, are normally performed in dedicated, closed units. Emissions from these units will be through process vents, to which PM controls can be applied relatively simply. Fugitive dust emissions may come from paved and unpaved roads in plants and from raw material and product loading, unloading, and storage (STAPPA/ALAPCO, 1996).

Cost estimates assume a conventional design under typical operating conditions. The costs do not include auxiliary equipment such as fans and ductwork. (EPA, 2000)

Costs are primarily based on volumetric flow rate and the amount of PM in the waste stream. In general, a small unit controlling a low pollutant levels will not be as cost effective as a large unit controlling a high pollutant levels. (EPA, 2000)

Pollutants requiring a high level of control or the fabric filters to be constructed of special materials will increase the costs of the system (EPA, 1998a). The additional costs for controlling complex waste streams are not included in the estimates. For these systems, the capital cost could increase by as much as 30% and the O&M cost could increase by as much as 7%.

In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Fabric filters may be in the form of sheets, cartridges, or bags, with many individual filter units together in a group. Bags are the most common type of filter. The dust cake that forms on the filter from the collected PM can significantly increase collection efficiency. (EPA, 2000)

Mechanical shaking is a popular cleaning method because it is both simple and effective. In typical operation, dusty gas enters an inlet pipe to the fabric filter and very large particles are removed using a baffle plate fall into the hopper. The gas stream is drawn from beneath a cell plate in the floor and into the filter bags (EPA, 2000). The gas proceeds from the inside to the outside of the filter bags. The particles collect on the inside of the bags, forming a filter cake. In mechanical shaking units, the tops of bags are attached to a shaker bar, moved briskly (usually in a horizontal direction) to clean the bags. The shaker bars are operated by mechanical motors or by hand (EPA, 1998b)..

Fabric filters are useful for collecting particles with resistivities either too low or too high for collection with electrostatic precipitators. Fabric filters are useful in controlling particulate matter less than or equal to 10 micrometers (μm) in diameter (PM10) and particulate matter less than or equal to 2.5 μm in diameter (PM2.5). Fabric filters may be good candidates for collecting fly ash from low-sulfur coals or containing high unburned carbon levels and are relatively difficult to collect with electrostatic precipitators. (EPA, 2000)

AT-A-GLANCE TABLE FOR POINT SOURCES

References:

EPA, 1998a: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, Chapter 5, EPA 453/B-96-001, Research Triangle Park, NC. December 1998.

EPA, 1998b: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

EPA, 2000: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Fabric Filter - Mechanical Shaker Cleaned Type," August 2000.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

STAPPA/ALAPCO, 1996: State and Territorial Air Pollution Program Administrators - Association of Local Air Pollution Control Officials, Controlling Particulate Matter Under the Clean Air Act: A Menu of Options, Washington, DC, July 1996.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Mineral Products - Stone Quarrying and Processing

Control Measure Name: Dry ESP-Wire Plate Type

Rule Name: Not Applicable

Pechan Measure Code: P2203

POD: 220

Application: This control is the use of dry electrostatic precipitators (ESP) to reduce PM emissions. An ESP uses electrical forces to move particles in an exhaust stream onto collector plates. Electrodes in the center of the flow are maintained at high voltage and generate an electrical field forcing particles to the collector walls. In dry ESPs, the collectors are knocked by various mechanical means to dislodge the particulate, which slides downward into a hopper.

This control applies to stone quarrying and processing operations. Nonmetallic Mineral Processing (305020) - ore crushing, grinding, and screening, and Calciners (SCC 305150) and Dryers (SCC 30502012) are considered in this category. Materials handling operations including crushing, grinding, and screening, can produce significant PM emissions.

Affected SCC:

30502001 Mineral Products, Stone Quarrying - Processing (See also 305320), Primary Crushing
30502002 Mineral Products, Stone Quarrying-Processing, Secondary Crushing/Screening
30502003 Mineral Products, Stone Quarrying-Processing, Tertiary Crushing/Screening
30502004 Stone Quarrying - Processing (See also 305320), Recrushing/Screening
30502005 Stone Quarrying - Processing (See also 305320), Fines Mill
30502006 Mineral Products, Stone Quarrying-Processing (See 305320), Misc. Operations
30502007 Stone Quarrying - Processing (See also 305320), Open Storage
30502008 Stone Quarrying - Processing (See also 305320), Cut Stone: General
30502009 Stone Quarrying - Processing (See also 305320), Blasting: General
30502010 Stone Quarrying - Processing (See also 305320), Drilling
30502011 Stone Quarrying - Processing (See also 305320), Hauling
30502012 Mineral Products, Stone Quarrying - Processing (See also 305320), Drying
30502013 Stone Quarrying - Processing (See also 305320), Bar Grizzlies
30502014 Stone Quarrying - Processing (See also 305320), Shaker Screens
30502015 Stone Quarrying - Processing (See also 305320), Vibrating Screens
30502017 Stone Quarrying - Processing (See also 305320), Pugmill
30502020 Stone Quarrying - Processing (See also 305320), Drilling
30502031 Stone Quarrying - Processing (See also 305320), Truck Unloading
30502033 Stone Quarrying - Processing (See also 305320), Truck Loading: Front End Loader
30502099 Stone Quarrying - Processing (See also 305320), Not Classified **

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: PM10 control efficiency is 98% from uncontrolled; PM2.5 control efficiency is 95% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

AT-A-GLANCE TABLE FOR POINT SOURCES

Cost Basis: The costs for ESPs of conventional design under typical operating conditions are developed using EPA cost estimating spreadsheets (EPA, 1996). When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan, 2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 1999). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$15 to \$50 per scfm
Typical value is \$27 per scfm

O&M Costs:

Range from \$4 to \$40 per scfm
Typical value is \$16 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for ESP (EPA, 1996). O&M costs were calculated for three model plants with flow rates of 200 and 500 thousand acfm and 1 million acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust loading of 6.0 grains per cubic feet. The operating time was assumed to be 8640 hours per year. The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.067	\$/kW-hr
Dust disposal	25	\$/ton disposed

Note: All costs are in 1995 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$40 to \$250 per ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$110 per ton PM10 reduced. (1995\$)

AT-A-GLANCE TABLE FOR POINT SOURCES

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

Minerals processing operations include drying, the heating of minerals or mineral products to remove water, and calcination, heating to higher temperatures to remove chemically bound water and other compounds, are normally performed in dedicated, closed units. Emissions from these units will be through process vents, to which PM controls can be applied relatively simply. Fugitive dust emissions may come from paved and unpaved roads in plants and from raw material and product loading, unloading, and storage (STAPPA/ALAPCO, 1996).

In the wire-plate ESP, the gas flows around vertical, metal plates. The electrodes are long, weighted wires hanging between the plates. The voltage applied to the electrodes causes the gas between the electrodes to break down, known as a "corona." The electrodes are most often given a negative polarity because a negative corona supports a higher voltage than a positive corona.

Certain types of losses affect control efficiency. The dislodging of the accumulated layer also projects some of the particles back into the gas stream. These particles are processed in later sections of the ESP, but the particles from the last section have no chance to be recaptured. Due to the space needed at the top of the ESP for nonelectrified components, part of the stream may flow around the charged zones. This is called "sneakage" and places an upper limit on the collection efficiency of the ESP. Anti-sneakage baffles are used to force the sneakage flow to mix with the main gas stream for collection in later sections (EPA, 1998).

Another factor in the performance of ESPs is the resistivity of the collected material. All the ion current must pass through the collected layer to reach the ground plates. This creates an electric field in the layer, and it can become large enough to cause electrical breakdown. When this occurs, new ions of the wrong polarity are injected into the wire-plate gap reducing the charge on the particles, which may cause sparking. This condition is called "back corona." When this happens the collection ability of the unit is reduced. At low resistivities the particles are held on the plates so loosely that reentrainment levels are much higher. Hence, care must be taken in measuring or estimating resistivity because it is strongly affected by such variables as temperature, moisture, gas composition, particle composition, and surface characteristics (EPA, 1999).

Dusts with high resistivities are also not well-suited for collection in dry ESPs. These particles are not easily charged nor easily collected. High-resistivity particles form ash layers with very high voltage gradients on the collecting electrodes lead to back corona, reducing the charge on particles and lowering collection efficiency. Fly ash from the combustion of low-sulfur coal typically has a high resistivity, and thus is difficult to collect using dry ESPs (EPA, 1999).

References:

EPA, 1996: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, EPA 453/B-96-001, Research Triangle Park, NC. February 1996.

EPA, 1998: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

EPA, 1999: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Dry Electrostatic Precipitator (ESP) - Wire-Plate Type," May 1999.

AT-A-GLANCE TABLE FOR POINT SOURCES

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

STAPPA/ALAPCO, 1996: State and Territorial Air Pollution Program Administrators - Association of Local Air Pollution Control Officials, Controlling Particulate Matter Under the Clean Air Act: A Menu of Options, Washington, DC, July 1996.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Mineral Products - Stone Quarrying and Processing

Control Measure Name: Wet ESP - Wire Plate Type

Rule Name: Not Applicable

Pechan Measure Code: P2204

POD: 220

Application: This control is the use of a wire-plate type electrostatic precipitator (ESP) to reduce PM emissions. An ESP uses electrical forces to move particles in an exhaust stream onto collector plates. Electrodes in the center of the flow are maintained at high voltage and generate an electrical field forcing particles to the collector walls. Wet ESPs use a stream of water, in place of rapping mechanisms, to dislodge particulate from the plates and into a sump.

This control applies to stone quarrying and processing operations, including (but not limited to) nonmetallic mineral processing (305020) - ore crushing, grinding, and screening, and calciners (SCC 305150) and dryers (SCC 30502012).

Affected SCC:

30502001 Mineral Products, Stone Quarrying - Processing (See also 305320), Primary Crushing
30502002 Mineral Products, Stone Quarrying-Processing, Secondary Crushing/Screening
30502003 Mineral Products, Stone Quarrying-Processing, Tertiary Crushing/Screening
30502004 Stone Quarrying - Processing (See also 305320), Recrushing/Screening
30502005 Stone Quarrying - Processing (See also 305320), Fines Mill
30502006 Mineral Products, Stone Quarrying-Processing (See 305320), Misc. Operations
30502007 Stone Quarrying - Processing (See also 305320), Open Storage
30502008 Stone Quarrying - Processing (See also 305320), Cut Stone: General
30502009 Stone Quarrying - Processing (See also 305320), Blasting: General
30502010 Stone Quarrying - Processing (See also 305320), Drilling
30502011 Stone Quarrying - Processing (See also 305320), Hauling
30502012 Mineral Products, Stone Quarrying - Processing (See also 305320), Drying
30502013 Stone Quarrying - Processing (See also 305320), Bar Grizzlies
30502014 Stone Quarrying - Processing (See also 305320), Shaker Screens
30502015 Stone Quarrying - Processing (See also 305320), Vibrating Screens
30502017 Stone Quarrying - Processing (See also 305320), Pugmill
30502020 Stone Quarrying - Processing (See also 305320), Drilling
30502031 Stone Quarrying - Processing (See also 305320), Truck Unloading
30502033 Stone Quarrying - Processing (See also 305320), Truck Loading: Front End Loader
30502099 Stone Quarrying - Processing (See also 305320), Not Classified **

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: PM10 control efficiency is 99% from uncontrolled; PM2.5 control efficiency is 95% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

AT-A-GLANCE TABLE FOR POINT SOURCES

Cost Basis: The following are cost ranges for wire-plate ESPs, developed using EPA cost-estimating spreadsheets for dry wire-plate ESPs with adjustments made to reflect wet wire-plate ESPs (EPA, 1999). Capital and operating costs are generally higher due to noncorrosive materials requirements, increased water usage, and treatment and disposal of wet effluent. When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM₁₀ removed were used (Pechan, 2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 1990). Total installed capital costs were annualized using a capital recovery factor, which is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$30 to \$60 per scfm
Typical value is \$40 per scfm

O&M Costs:

Range from \$6 to \$45 per scfm
Typical value is \$19 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for ESP (EPA, 1999). O&M costs were calculated for three model plants with flow rates of 10, 15 and 20 thousand acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust loading of 6.0 grains per cubic feet. The operating time was assumed to be 8640 hours per year. A water flow rate for the ESP was assumed to be 5 gal/min per thousand acfm. The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.067	\$/kW-hr
Process water price	0.20	\$/1000 gal
Dust disposal	20	\$/ton disposed
Wastewater treatment	1.5	\$/ thousand gal treated

Note: All costs are in 1995 dollars.

AT-A-GLANCE TABLE FOR POINT SOURCES

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$55 to \$550 per ton PM₁₀ removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$220 per ton PM₁₀ reduced. (1995\$)

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

Materials handling operations including crushing, grinding, and screening, can produce significant PM emissions. Drying, the heating of minerals or mineral products to remove water, and calcination, heating to higher temperatures to remove chemically bound water and other compounds, are normally performed in dedicated, closed units. Emissions from these units will be through process vents, to which PM controls can be applied relatively simply. Fugitive dust emissions may come from paved and unpaved roads in plants and from raw material and product loading, unloading, and storage (STAPPA/ALAPCO, 1996).

Costs can be substantially higher than in the ranges shown for pollutants which require an unusually high level of control, or which require the ESP to be constructed of special materials such as titanium (EPA, 1999). In most cases, smaller units controlling a low concentration waste stream will not be as cost effective as a large unit cleaning a high pollutant load flow (EPA, 1998).

In the wire-plate ESP, the gas flows around vertical, metal plates. The electrodes are long, weighted wires hanging between the plates. The voltage applied to the electrodes causes the gas between the electrodes to break down, known as a "corona." The electrodes are most often given a negative polarity because a negative corona supports a higher voltage than a positive corona.

Certain types of losses affect control efficiency. The dislodging of the accumulated layer also projects some of the particles back into the gas stream. These particles are processed in later sections of the ESP, but the particles from the last section have no chance to be recaptured. Due to the space needed at the top of the ESP for nonelectrified components, part of the stream may flow around the charged zones. This is called "sneakage" and places an upper limit on the collection efficiency of the ESP. Anti-sneakage baffles are used to force the sneakage flow to mix with the main gas stream for collection in later sections (EPA, 1998).

Wire-Plate Type Wet ESPs require a source of wash water near the top of the collector plates. This wash system replaces the rapping mechanism used by dry ESPs. The water flows with the collected particles into a sump from which the fluid is pumped or drained. A portion of the fluid may be recycled to reduce the total amount of water required. The remainder is pumped into a settling pond or passed through a dewatering stage, with subsequent disposal of the sludge (AWMA, 1992).

Unlike dry ESPs, resistivity of the collected material is not a major factor in performance. Because of the high humidity in a wet ESP, the resistivity of particles is lowered, eliminating the "back corona" condition. The frequent washing of the plates also limits particle buildup on the collectors (EPA, 1998).

For wet ESPs, the handling wastewaters must be considered (EPA, 1999). For simple systems with innocuous dusts, water with particles collected by the ESP may be discharged from the ESP system to a solids-removing clarifier. More complicated systems may require skimming and sludge removal, clarification in dedicated equipment, pH adjustment, and/or treatment to remove dissolved solids. Recirculation of treated water to the ESP may approach 100 percent (AWMA, 1992).

AT-A-GLANCE TABLE FOR POINT SOURCES

References:

AWMA, 1992: Air & Waste Management Association, Air Pollution Engineering Manual, Van Nostrand Reinhold, New York.

EPA, 1996: U.S. EPA, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, EPA 453/B-96-001, Research Triangle Park, NC. February.

EPA, 1998: U.S. EPA, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October.

EPA, 1999: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Wet Electrostatic Precipitator (ESP) - Wire-Plate Type," May 1999

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

STAPPA/ALAPCO, 1996: State and Territorial Air Pollution Program Administrators - Association of Local Air Pollution Control Officials, "Controlling Particulate Matter Under the Clean Air Act: A Menu of Options", Washington, DC, July 1996.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Mineral Products - Stone Quarrying and Processing

Control Measure Name: Paper/Nonwoven Filters - Cartridge Collector Type

Rule Name: Not Applicable

Pechan Measure Code: P2205

POD: 220

Application: This control is the use of paper or non-woven filters (cartridge collector type) to reduce PM emissions. The waste gas stream is passed through the fibrous filter media causing PM in the gas stream to be collected on the media by sieving and other mechanisms.

This control measure applies to stone quarrying and processing operations. Nonmetallic mineral processing (305020) operations include, but are not limited to, ore crushing, grinding, and screening, and calciners (SCC 305150) and dryers (SCC 30502012).

Affected SCC:

30502001 Mineral Products, Stone Quarrying - Processing (See also 305320), Primary Crushing
30502002 Mineral Products, Stone Quarrying-Processing, Secondary Crushing/Screening
30502003 Mineral Products, Stone Quarrying-Processing, Tertiary Crushing/Screening
30502004 Stone Quarrying - Processing (See also 305320), Recrushing/Screening
30502005 Stone Quarrying - Processing (See also 305320), Fines Mill
30502006 Mineral Products, Stone Quarrying-Processing (See 305320), Misc. Operations
30502007 Stone Quarrying - Processing (See also 305320), Open Storage
30502008 Stone Quarrying - Processing (See also 305320), Cut Stone: General
30502009 Stone Quarrying - Processing (See also 305320), Blasting: General
30502010 Stone Quarrying - Processing (See also 305320), Drilling
30502011 Stone Quarrying - Processing (See also 305320), Hauling
30502012 Mineral Products, Stone Quarrying - Processing (See also 305320), Drying
30502013 Stone Quarrying - Processing (See also 305320), Bar Grizzlies
30502014 Stone Quarrying - Processing (See also 305320), Shaker Screens
30502015 Stone Quarrying - Processing (See also 305320), Vibrating Screens
30502017 Stone Quarrying - Processing (See also 305320), Pugmill
30502020 Stone Quarrying - Processing (See also 305320), Drilling
30502031 Stone Quarrying - Processing (See also 305320), Truck Unloading
30502033 Stone Quarrying - Processing (See also 305320), Truck Loading: Front End Loader
30502099 Stone Quarrying - Processing (See also 305320), Not Classified **

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 99% from uncontrolled for both PM10 and PM2.5

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs are generated using EPA's cost-estimating spreadsheets for fabric filters (EPA, 1998a). Costs are primarily driven by the waste stream volumetric flow rate and pollutant loading. When stack gas flow rate data was available, the costs and

AT-A-GLANCE TABLE FOR POINT SOURCES

cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan,2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 2000). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$7 to \$13 per scfm
Typical value is \$9 per scfm

O&M Costs:

Range from \$9 to \$25 per scfm
Typical value is \$14 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). O&M costs were calculated for three model plants with flow rates of 25, 75 and 150 thousand acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust loading of 4.0 grains per cubic feet. The operating time was assumed to be 8760 hours per year. An average cartridge cost was estimated using the costs for standard cartridge types. Capital recovery for the periodic replacement of cartridges was included in the O&M cost of the cartridges using a cartridge life of 2 years (EPA, 1998a). The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.0671	\$/kW-hr
Compressed air	0.25	\$/1000 scf
Dust disposal	25	\$/ton disposed

Note: All costs are in 1998 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$85 to \$256 per ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$142 per ton PM10 reduced. (1998\$)

AT-A-GLANCE TABLE FOR POINT SOURCES

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

Materials handling operations including crushing, grinding, and screening, can produce significant PM emissions. Drying, the heating of minerals or mineral products to remove water, and calcination, heating to higher temperatures to remove chemically bound water and other compounds, are normally performed in dedicated, closed units. Emissions from these units will be through process vents, to which PM controls can be applied relatively simply. Fugitive dust emissions may come from paved and unpaved roads in plants and from raw material and product loading, unloading, and storage (STAPPA/ALAPCO, 1996).

The cost estimates assume a conventional design under typical operating conditions. Auxiliary equipment, such as fans and ductwork, is not included (EPA, 2000). Pollutants that require an unusually high level of control or that require the filter media or the unit itself to be constructed of special materials, such as Nomex ® or stainless steel, will increase the costs of the system (EPA, 1998a). The additional costs for controlling more complex waste streams are not reflected in the estimates given below. For these types of systems, the capital cost could increase by as much as 75% and the O&M cost could increase by as much as 10%. In general, a small unit controlling a low pollutant loading will not be as cost effective as a large unit controlling a high pollutant loading (EPA, 2000).

Cartridge filters contain either a paper or nonwoven fibrous filter media (EPA, 2000). Paper media is generally made of materials such as cellulose and fiberglass. The dust cake that forms on the filter media from the collected PM can significantly increase collection efficiency (EPA, 1998b).

In general, the filter media is pleated to provide a larger surface area to volume flow rate. Close pleating, however, can cause PM to bridge the pleat bottom, effectively reducing the surface collection area (EPA, 1998b). Corrugated aluminum separators are used to prevent the pleats from collapsing (Heumann, 1997). There are variety of cartridge designs and dimensions. Typical designs include flat panels, V-shaped packs or cylindrical packs (Heumann, 1997). For certain applications, two cartridges may be placed in series.

Cartridge collectors are useful for collecting particles with resistivities either too low or too high for collection with electrostatic precipitators (STAPPA/ALAPCO, 1996). For similar air flow rates, cartridge collectors are compact in size compared to traditional bag

References:

EPA, 1998b: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, Chapter 5, EPA 453/B-96-001, Research Triangle Park, NC. December 1998.

EPA, 1998a: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

EPA, 2000: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Cartridge Collector with Pulse-Jet Cleaning," April 2000.

Heumann, 1997: W. L. Heumann, "Industrial Air Pollution Control Systems," McGraw Hill Publishers, Inc., Washington, D.C., 1997.

AT-A-GLANCE TABLE FOR POINT SOURCES

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

STAPPA/ALAPCO, 1996: State and Territorial Air Pollution Program Administrators and Association of Local Air Pollution Control Officials, "Controlling Particulate Matter Under the Clean Air Act: A Menu of Options," July 1996.

STAPPA/ALAPCO, 1996: State and Territorial Air Pollution Program Administrators - Association of Local Air Pollution Control Officials, Controlling Particulate Matter Under the Clean Air Act: A Menu of Options, Washington, DC, July 1996.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Mineral Products - Stone Quarrying and Processing

Control Measure Name: Fabric Filter (Reverse-Air Cleaned Type)

Rule Name: Not Applicable

Pechan Measure Code: P2206

POD: 220

Application: This control is the use of a reverse-air cleaned fabric filter to reduce PM emissions from waste streams. In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Reverse-air cleaning is performed by forcing clean air through the filters in the opposite direction of the dusty gas flow. The change in direction of the gas flow causes the bag to flex and crack the filter cake allowing for internal cake collection.

This control applies to ferroalloy production operations, including (but not limited to) nonmetallic mineral processing (305020) - ore crushing, grinding, and screening, and calciners (SCC 305150) and dryers (SCC 30502012). Materials handling operations including crushing, grinding, and screening, can produce significant PM emissions.

Affected SCC:

30502001 Mineral Products, Stone Quarrying - Processing (See also 305320), Primary Crushing
30502002 Mineral Products, Stone Quarrying-Processing, Secondary Crushing/Screening
30502003 Mineral Products, Stone Quarrying-Processing, Tertiary Crushing/Screening
30502004 Stone Quarrying - Processing (See also 305320), Recrushing/Screening
30502005 Stone Quarrying - Processing (See also 305320), Fines Mill
30502006 Mineral Products, Stone Quarrying-Processing (See 305320), Misc. Operations
30502007 Stone Quarrying - Processing (See also 305320), Open Storage
30502008 Stone Quarrying - Processing (See also 305320), Cut Stone: General
30502009 Stone Quarrying - Processing (See also 305320), Blasting: General
30502010 Stone Quarrying - Processing (See also 305320), Drilling
30502011 Stone Quarrying - Processing (See also 305320), Hauling
30502012 Mineral Products, Stone Quarrying - Processing (See also 305320), Drying
30502013 Stone Quarrying - Processing (See also 305320), Bar Grizzlies
30502014 Stone Quarrying - Processing (See also 305320), Shaker Screens
30502015 Stone Quarrying - Processing (See also 305320), Vibrating Screens
30502017 Stone Quarrying - Processing (See also 305320), Pugmill
30502020 Stone Quarrying - Processing (See also 305320), Drilling
30502031 Stone Quarrying - Processing (See also 305320), Truck Unloading
30502033 Stone Quarrying - Processing (See also 305320), Truck Loading: Front End Loader
30502099 Stone Quarrying - Processing (See also 305320), Not Classified **

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 99% from uncontrolled for both PM10 and PM2.5

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

AT-A-GLANCE TABLE FOR POINT SOURCES

Cost Basis: The costs for reverse-air cleaned systems are generated using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM₁₀ removed were used (Pechan, 2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 2000). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$9 to \$84 per scfm

Typical value is \$34 per scfm

O&M Costs:

Range from \$6 to \$27 per scfm

Typical value is \$13 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). O&M costs were calculated for three model plants with flow rates of 25, 75 and 150 thousand acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust loading of 4.0 grains per cubic feet. The operating time was assumed to be 8760 hours per year. An average bag cost was estimated using the costs for standard bag types. Capital recovery for the periodic replacement of bags was included in the O&M cost of the bags using a bag life of 2 years (EPA, 1998a). The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.0671	\$/kW-hr
Compressed air	0.25	\$/1000 scf
Dust disposal	25	\$/ton disposed

Note: All costs are in 1998 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$53 to \$337 per

AT-A-GLANCE TABLE FOR POINT SOURCES

ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$148 per ton PM10 reduced. (1998\$)

Comments:

Status: Demonstrated**Last Reviewed:** 2001

Additional Information:

Drying, the heating of minerals or mineral products to remove water, and calcination, heating to higher temperatures to remove chemically bound water and other compounds, are normally performed in dedicated, closed units. Emissions from these units will be through process vents, to which PM controls can be applied relatively simply. Fugitive dust emissions may come from paved and unpaved roads in plants and from raw material and product loading, unloading, and storage (STAPPA/ALAPCO, 1996)..

The cost estimates assume a conventional design under typical operating conditions. The costs do not include any auxiliary equipment (EPA, 2000).

The capital cost for the reverse-jet cleaned fabric baghouse is based on information provided by a manufacturer (EPA, 2000). The capital cost includes only the purchased equipment cost.

Costs are primarily based on volumetric flow rate and the amount of PM in the waste stream. In general, a small unit controlling a low pollutant levels will not be as cost effective as a large unit controlling a high pollutant levels. (EPA, 2000)

Pollutants requiring a high level of control or the fabric filters to be constructed of special materials will increase the costs of the system (EPA, 1998a). The additional costs for controlling complex streams are not reflected in the estimates. For these systems, the capital cost could increase by as much as 40% and the O&M cost could increase by as much as 5%. (EPA, 2000)

In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Fabric filters may be in the form of sheets, cartridges, or bags, with many individual filter units together in a group. Bags are the most common type of filter. The dust cake that forms on the filter from the collected PM can significantly increase collection efficiency. (EPA, 2000)

Reverse-air cleaning is a popular filter cleaning method as it has been used extensively and improved over the years. It is a gentler but sometimes less effective clearing mechanism than mechanical shaking. Reverse-air cleaning is performed by forcing clean air through the filters in the opposite direction of the dusty gas flow. The change in direction of the gas flow causes the bag to flex and crack the filter cake allowing for internal cake collection (EPA, 2000).

The most common design is to have separate compartments within the fabric filter so that each can be isolated and cleaned separately while the others continue to treat the dusty gas. There are several methods of reversing the flow through the filters. One method of providing the reverse flow is by the use of a fan or cleaned gas from other compartments. Reverse-air cleaning only used alone in cases where the dust releases easily from the fabric. In many instances, reverse-air is used along with shaking, pulsing or sonic horns (EPA, 1998b).

Fabric filters are useful for collecting particles with resistivities either too low or too high for collection with electrostatic precipitators. Fabric filters are useful in controlling particulate matter less than or equal to 10 micrometers (μm) in diameter (PM10) and particulate matter less than or equal to 2.5

AT-A-GLANCE TABLE FOR POINT SOURCES

µm in diameter (PM_{2.5}). Fabric filters may be good candidates for collecting fly ash from low-sulfur coals or containing high unburned carbon levels and are relatively difficult to collect with electrostatic precipitators. (EPA, 2000)

References:

EPA, 1998b: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

EPA, 1998a: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, Chapter 5, EPA 453/B-96-001, Research Triangle Park, NC. December 1998.

EPA, 2000: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Fabric Filter - Reverse-Air Cleaned Type," April 2000.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

STAPPA/ALAPCO, 1996: State and Territorial Air Pollution Program Administrators - Association of Local Air Pollution Control Officials, Controlling Particulate Matter Under the Clean Air Act: A Menu of Options, Washington, DC, July 1996.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Mineral Products - Stone Quarrying and Processing

Control Measure Name: Venturi Scrubber

Rule Name: Not Applicable

Pechan Measure Code: P2207

POD: 220

Application: The control is the use of a venturi scrubber to reduce PM emissions. A scrubber is a type of technology that removes air pollutants by inertial and diffusional interception. A venturi scrubber accelerates the waste gas stream to atomize the scrubbing liquid and to improve gas-liquid contact.

This control applies to stone quarrying and processing operations, including (but not limited to) nonmetallic mineral processing (305020) - ore crushing, grinding, and screening, and calciners (SCC 305150) and dryers (SCC 30502012).

Affected SCC:

30502001 Mineral Products, Stone Quarrying - Processing (See also 305320), Primary Crushing
30502002 Mineral Products, Stone Quarrying-Processing, Secondary Crushing/Screening
30502003 Mineral Products, Stone Quarrying-Processing, Tertiary Crushing/Screening
30502004 Stone Quarrying - Processing (See also 305320), Recrushing/Screening
30502005 Stone Quarrying - Processing (See also 305320), Fines Mill
30502006 Mineral Products, Stone Quarrying-Processing (See 305320), Misc. Operations
30502007 Stone Quarrying - Processing (See also 305320), Open Storage
30502008 Stone Quarrying - Processing (See also 305320), Cut Stone: General
30502009 Stone Quarrying - Processing (See also 305320), Blasting: General
30502010 Stone Quarrying - Processing (See also 305320), Drilling
30502011 Stone Quarrying - Processing (See also 305320), Hauling
30502012 Mineral Products, Stone Quarrying - Processing (See also 305320), Drying
30502013 Stone Quarrying - Processing (See also 305320), Bar Grizzlies
30502014 Stone Quarrying - Processing (See also 305320), Shaker Screens
30502015 Stone Quarrying - Processing (See also 305320), Vibrating Screens
30502020 Stone Quarrying - Processing (See also 305320), Drilling
30502031 Stone Quarrying - Processing (See also 305320), Truck Unloading
30502033 Stone Quarrying - Processing (See also 305320), Truck Loading: Front End Loader
30502099 Stone Quarrying - Processing (See also 305320), Not Classified **

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: PM10 control efficiency is 95% from uncontrolled; PM2.5 control efficiency is 90% from uncontrolled

Equipment Life: 10 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The following are cost ranges for venturi wet scrubbers, developed using EPA cost-estimating spreadsheets (EPA, 1996) and referenced to the volumetric flow rate of the waste stream treated. When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M

AT-A-GLANCE TABLE FOR POINT SOURCES

costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan,2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 1999). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (10 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$3 to \$28 per scfm
Typical value is \$11 per scfm

O&M Costs:

Range from \$4 to \$119 per scfm
Typical value is \$42 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for Impingement Plate Scrubbers (EPA, 1996). O&M costs were calculated for two model plants with flow rates of 2,000 and 150,000 acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. The model plants were assumed to have a dust loading of 3.0 grains per cubic feet. The operating time was assumed to be 8760 hours per year. An inlet water flow rate for the scrubber was assumed to be 9.4 lbs/min. The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.067	\$/kW-hr
Process water price	0.20	\$/1000 gal
Dust disposal	25	\$/ton disposed
Wastewater treatment	3.8	\$/ thousand gal treated

Note: All costs are in 1995 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$76 to \$2,100 per ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$751 per ton PM10 reduced. (1995\$)

Comments:

AT-A-GLANCE TABLE FOR POINT SOURCES

Status: Demonstrated	Last Reviewed: 2001
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Additional Information:

Materials handling operations including crushing, grinding, and screening, can produce significant PM emissions. Drying, the heating of minerals or mineral products to remove water, and calcination, heating to higher temperatures to remove chemically bound water and other compounds, are normally performed in dedicated, closed units. Emissions from these units will be through process vents, to which PM controls can be applied relatively simply. Fugitive dust emissions may come from paved and unpaved roads in plants and from raw material and product loading, unloading, and storage (STAPPA/ALAPCO, 1996).

The costs do not include costs for post-treatment or disposal of used solvent or waste. Actual costs can be substantially higher than in the ranges shown for applications which require expensive materials, solvents, or treatment methods (EPA, 1999). As a rule, smaller units controlling a low concentration waste stream will be much more expensive (per unit volumetric flow rate) than a large unit cleaning a high pollutant load flow.

By product coke production is used to manufacture metallurgical coke by heating high-grade bituminous coal (low sulfur and low ash) in an enclosed oven chamber without oxygen. The resulting solid material consists of elemental carbon and any minerals (ash) that were present in the coal blend that did not volatilize during the process. Sources of air emissions consist of coke oven doors, coke oven lids and off-takes, coke oven charging, coke oven pushing, coke oven underfire stack, coke quenching, battery venting, and coke by-product-recovery plants.

A venturi scrubber accelerates the waste gas stream to improve gas-liquid contact. In a venturi scrubber, a "throat" section is built into the duct that forces the gas stream to accelerate (EPA, 1999). As the gas enters the venturi throat, both gas velocity and turbulence increase.

After the throat section, the mixture decelerates, and further impacts occur causing the droplets to agglomerate. Once the particles have been captured by the liquid, the wetted PM and excess liquid are separated from the gas stream through entrainment. This section usually consists of a cyclonic separator and/or a mist eliminator (EPA, 1998; Corbitt, 1990).

For PM applications, wet scrubbers generate waste, either a slurry or wet sludge. This creates the need for both wastewater treatment and solid waste disposal. Initially, the slurry is treated to separate the solid waste from the water (EPA, 1999). The treated water can then be reused or discharged. Once the water is removed, the remaining waste will be in the form of a solid or sludge. If the solid waste is inert and nontoxic, it can generally be land filled. Hazardous wastes will have more stringent procedures for disposal. In some cases, the solid waste may have value and can be sold or recycled (EPA, 1998).

References:

Corbitt, 1990: "Standard Handbook of Environmental Engineering," edited by Robert A. Corbitt, McGraw-Hill, New York, NY, 1990.

EPA, 1996: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, EPA 453/B-96-001, Research Triangle Park, NC February.

EPA, 1998: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

AT-A-GLANCE TABLE FOR POINT SOURCES

EPA, 1999: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Venturi Scrubber," July 1999.

Heumann, 1997: W. L. Heumann, "Industrial Air Pollution Control Systems," McGraw Hill Publishers, Inc., Washington, D.C., 1997.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

STAPPA/ALAPCO, 1996: State and Territorial Air Pollution Program Administrators - Association of Local Air Pollution Control Officials, "Controlling Particulate Matter Under the Clean Air Act: A Menu of Options," Washington, DC, July 1996.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Municipal Waste Incineration

Control Measure Name: Dry ESP-Wire Plate Type

Rule Name: Not Applicable

Pechan Measure Code: P2261

POD: 226

Application: This control is the use of dry electrostatic precipitators (ESP) to reduce PM emissions. An ESP uses electrical forces to move particles in an exhaust stream onto collector plates. Electrodes in the center of the flow are maintained at high voltage and generate an electrical field forcing particles to the collector walls. In dry ESPs, the collectors are knocked by various mechanical means to dislodge the particulate, which slides downward into a hopper.

This control applies to municipal waste incineration operations classified under SCCs: 50100101, 50100102, 50100103, 50100105, and 50100107.

Affected SCC:

50100101 Solid Waste Disposal-Gov't, Municipal Incineration, Starved Air-Multiple Chamber

50100102 Municipal Incineration, Mass Burn: Single Chamber

50100103 Municipal Incineration, Refuse Derived Fuel

50100105 Municipal Incineration, Mass Burn Waterwall Combustor

50100107 Municipal Incineration, Modular Excess Air Combustor

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√							

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: PM10 control efficiency is 98% from uncontrolled; PM2.5 control efficiency is 95% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs for ESPs of conventional design under typical operating conditions are developed using EPA cost estimating spreadsheets (EPA, 1996). When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan, 2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 1999). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets

AT-A-GLANCE TABLE FOR POINT SOURCES

were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$15 to \$50 per scfm
Typical value is \$27 per scfm

O&M Costs:

Range from \$4 to \$40 per scfm
Typical value is \$16 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for ESP (EPA, 1996). O&M costs were calculated for three model plants with flow rates of 200 and 500 thousand acfm and 1 million acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust loading of 6.0 grains per cubic feet. The operating time was assumed to be 8640 hours per year. The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.067	\$/kW-hr
Dust disposal	25	\$/ton disposed

Note: All costs are in 1995 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$40 to \$250 per ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$110 per ton PM10 reduced. (1995\$)

Comments:

Status: Demonstrated	Last Reviewed: 2001
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Additional Information:

In the wire-plate ESP, the gas flows around vertical, metal plates. The electrodes are long, weighted wires hanging between the plates. The voltage applied to the electrodes causes the gas between the electrodes to break down, known as a "corona." The electrodes are most often given a negative polarity because a negative corona supports a higher voltage than a positive corona.

Certain types of losses affect control efficiency. The dislodging of the accumulated layer also projects some of the particles back into the gas stream. These particles are processed in later sections of the ESP, but the particles from the last section have no chance to be recaptured. Due to the space needed at the top of the ESP for nonelectrified components, part of the stream may flow around the charged zones. This is called "sneakage" and places an upper limit on the collection efficiency of the ESP. Anti-sneakage baffles are used to force the sneakage flow to mix with the

AT-A-GLANCE TABLE FOR POINT SOURCES

main gas stream for collection in later sections (EPA, 1998).

Another factor in the performance of ESPs is the resistivity of the collected material. All the ion current must pass through the collected layer to reach the ground plates. This creates an electric field in the layer, and it can become large enough to cause electrical breakdown. When this occurs, new ions of the wrong polarity are injected into the wire-plate gap reducing the charge on the particles, which may cause sparking. This condition is called "back corona." When this happens the collection ability of the unit is reduced. At low resistivities the particles are held on the plates so loosely that reentrainment levels are much higher. Hence, care must be taken in measuring or estimating resistivity because it is strongly affected by such variables as temperature, moisture, gas composition, particle composition, and surface characteristics (EPA, 1999).

Dusts with high resistivities are also not well-suited for collection in dry ESPs. These particles are not easily charged nor easily collected. High-resistivity particles form ash layers with very high voltage gradients on the collecting electrodes lead to back corona, reducing the charge on particles and lowering collection efficiency. Fly ash from the combustion of low-sulfur coal typically has a high resistivity, and thus is difficult to collect using dry ESPs (EPA, 1999).

References:

EPA, 1996: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, EPA 453/B-96-001, Research Triangle Park, NC. February 1996.

EPA, 1998: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

EPA, 1999: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Dry Electrostatic Precipitator (ESP) - Wire-Plate Type," May 1999.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Non-Ferrous Metals Processing - Aluminum

Control Measure Name: Fabric Filter (Mech. Shaker Type)

Rule Name: Not Applicable

Pechan Measure Code: P2111

POD: 211

Application: This control is the addition of a mechanical shaker type fabric filter to reduce PM emissions. In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. The gas stream is drawn from beneath a cell plate in the floor and into the filter bags. The gas proceeds from the inside to the outside of the filter bags. The particles collect on the inside of the bags, forming a filter cake. In mechanical shaking units, the tops of bags are attached to a shaker bar, moved briskly to clean the bags.

This control applies to aluminum processing and production operations.

Affected SCC:

30300001 Aluminum Ore (Bauxite), Crushing/Handling
30300002 Aluminum Ore (Bauxite), Drying Oven
30300003 Aluminum Ore (Bauxite), Fine Ore Storage
30300101 Primary Metal Production, Aluminum Ore (Electro-reduction), Prebaked Reduction Cell
30300102 Aluminum Ore (Electro-reduction), Horizontal Stud Soderberg Cell
30300103 Aluminum Ore (Electro-reduction), Vertical Stud Soderberg Cell
30300104 Primary Metal Production, Aluminum Ore (Electro-reduction), Materials Handling
30300105 Primary Metal Production, Aluminum Ore (Electro-reduction), Anode Baking Furnace
30300106 Aluminum Ore (Electro-reduction), Degassing
30300107 Aluminum Ore (Electro-reduction), Roof Vents
30300108 Aluminum Ore (Electro-reduction), Prebake: Fugitive Emissions
30300109 Aluminum Ore (Electro-reduction), H.S.S.: Fugitive Emissions
30300110 Aluminum Ore (Electro-reduction), V.S.S.: Fugitive Emissions
30300199 Aluminum Ore (Electro-reduction), Not Classified **
30300201 Aluminum Hydroxide Calcining, Overall Process

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 99% from uncontrolled for both PM10 and PM2.5

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs for mechanical shaker cleaned systems are generated using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan,2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed

AT-A-GLANCE TABLE FOR POINT SOURCES

capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 2000).. Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$8 to \$71 per scfm
Typical value is \$29 per scfm

O&M Costs:

Range from \$4 to \$24 per scfm
Typical value is \$11 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). O&M costs were calculated for three model plants with flow rates of 25, 75 and 150 thousand acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust loading of 4.0 grains per cubic feet. The operating time was assumed to be 8760 hours per year. An average bag cost was estimated using the costs for standard bag types. Capital recovery for the periodic replacement of bags was included in the O&M cost of the bags using a bag life of 2 years (EPA, 1998a). The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.0671	\$/kW-hr
Compressed air	0.25	\$/1000 scf
Dust disposal	25	\$/ton disposed

Note: All costs are in 1998 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$37 to \$303 per ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$126 per ton PM10 reduced. (1998\$)

Comments:

Status: Demonstrated	Last Reviewed: 2001
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AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

Cost estimates assume a conventional design under typical operating conditions. The costs do not include auxiliary equipment such as fans and ductwork. (EPA, 2000)

Costs are primarily based on volumetric flow rate and the amount of PM in the waste stream. In general, a small unit controlling a low pollutant levels will not be as cost effective as a large unit controlling a high pollutant levels. (EPA, 2000)

Pollutants requiring a high level of control or the fabric filters to be constructed of special materials will increase the costs of the system (EPA, 1998a). The additional costs for controlling complex waste streams are not included in the estimates. For these systems, the capital cost could increase by as much as 30% and the O&M cost could increase by as much as 7%.

In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Fabric filters may be in the form of sheets, cartridges, or bags, with many individual filter units together in a group. Bags are the most common type of filter. The dust cake that forms on the filter from the collected PM can significantly increase collection efficiency. (EPA, 2000)

Mechanical shaking is a popular cleaning method because it is both simple and effective. In typical operation, dusty gas enters an inlet pipe to the fabric filter and very large particles are removed using a baffle plate fall into the hopper. The gas stream is drawn from beneath a cell plate in the floor and into the filter bags (EPA, 2000). The gas proceeds from the inside to the outside of the filter bags. The particles collect on the inside of the bags, forming a filter cake. In mechanical shaking units, the tops of bags are attached to a shaker bar, moved briskly (usually in a horizontal direction) to clean the bags. The shaker bars are operated by mechanical motors or by hand (EPA, 1998b)..

Fabric filters are useful for collecting particles with resistivities either too low or too high for collection with electrostatic precipitators. Fabric filters are useful in controlling particulate matter less than or equal to 10 micrometers (μm) in diameter (PM10) and particulate matter less than or equal to 2.5 μm in diameter (PM2.5). Fabric filters may be good candidates for collecting fly ash from low-sulfur coals or containing high unburned carbon levels and are relatively difficult to collect with electrostatic precipitators. (EPA, 2000)

References:

EPA, 1998a: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, Chapter 5, EPA 453/B-96-001, Research Triangle Park, NC. December 1998.

EPA, 1998b: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

EPA, 2000: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Fabric Filter - Mechanical Shaker Cleaned Type," August 2000.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Non-Ferrous Metals Processing - Aluminum

Control Measure Name: Dry ESP-Wire Plate Type

Rule Name: Not Applicable

Pechan Measure Code: P2112

POD: 211

Application: This control is the use of dry electrostatic precipitators (ESP) to reduce PM emissions. An ESP uses electrical forces to move particles in an exhaust stream onto collector plates. Electrodes in the center of the flow are maintained at high voltage and generate an electrical field forcing particles to the collector walls. In dry ESPs, the collectors are knocked by various mechanical means to dislodge the particulate, which slides downward into a hopper.

This control applies to aluminum processing operations.

Affected SCC:

30300001 Aluminum Ore (Bauxite), Crushing/Handling
30300002 Aluminum Ore (Bauxite), Drying Oven
30300003 Aluminum Ore (Bauxite), Fine Ore Storage
30300101 Primary Metal Production, Aluminum Ore (Electro-reduction), Prebaked Reduction Cell
30300102 Aluminum Ore (Electro-reduction), Horizontal Stud Soderberg Cell
30300103 Aluminum Ore (Electro-reduction), Vertical Stud Soderberg Cell
30300104 Primary Metal Production, Aluminum Ore (Electro-reduction), Materials Handling
30300105 Primary Metal Production, Aluminum Ore (Electro-reduction), Anode Baking Furnace
30300106 Aluminum Ore (Electro-reduction), Degassing
30300107 Aluminum Ore (Electro-reduction), Roof Vents
30300108 Aluminum Ore (Electro-reduction), Prebake: Fugitive Emissions
30300109 Aluminum Ore (Electro-reduction), H.S.S.: Fugitive Emissions
30300110 Aluminum Ore (Electro-reduction), V.S.S.: Fugitive Emissions
30300199 Aluminum Ore (Electro-reduction), Not Classified **
30300201 Aluminum Hydroxide Calcining, Overall Process

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: PM10 control efficiency is 98% from uncontrolled; PM2.5 control efficiency is 95% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs for ESPs of conventional design under typical operating conditions are developed using EPA cost estimating spreadsheets (EPA, 1996). When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan, 2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed

AT-A-GLANCE TABLE FOR POINT SOURCES

capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 1999). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$15 to \$50 per scfm
Typical value is \$27 per scfm

O&M Costs:

Range from \$4 to \$40 per scfm
Typical value is \$16 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for ESP (EPA, 1996). O&M costs were calculated for three model plants with flow rates of 200 and 500 thousand acfm and 1 million acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust loading of 6.0 grains per cubic feet. The operating time was assumed to be 8640 hours per year. The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.067	\$/kW-hr
Dust disposal	25	\$/ton disposed

Note: All costs are in 1995 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$40 to \$250 per ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$110 per ton PM10 reduced. (1995\$)

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

The costs for ESPs of conventional design under typical operating conditions are developed using EPA cost estimating spreadsheets (EPA, 1996). When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs.

AT-A-GLANCE TABLE FOR POINT SOURCES

When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan,2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 1990). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$15 to \$50 per scfm
Typical value is \$27 per scfm

O&M Costs:

Range from \$4 to \$40 per scfm
Typical value is \$16 per scfm

Note: All costs are in 1995 dollars.

References:

EPA, 1996: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, EPA 453/B-96-001, Research Triangle Park, NC. February 1996.

EPA, 1998: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

EPA, 1999: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Dry Electrostatic Precipitator (ESP) - Wire-Plate Type," May 1999.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Non-Ferrous Metals Processing - Aluminum

Control Measure Name: Wet ESP - Wire Plate Type

Rule Name: Not Applicable

Pechan Measure Code: P2113

POD: 211

Application: This control is the use of a wire-plate type electrostatic precipitator (ESP) to reduce PM emissions. An ESP uses electrical forces to move particles in an exhaust stream onto collector plates. Electrodes in the center of the flow are maintained at high voltage and generate an electrical field forcing particles to the collector walls. Wet ESPs use a stream of water, in place of rapping mechanisms, to dislodge particulate from the plates and into a sump.

This control applies to aluminum processing and production operations.

Affected SCC:

30300001 Aluminum Ore (Bauxite), Crushing/Handling
30300002 Aluminum Ore (Bauxite), Drying Oven
30300003 Aluminum Ore (Bauxite), Fine Ore Storage
30300101 Primary Metal Production, Aluminum Ore (Electro-reduction), Prebaked Reduction Cell
30300102 Aluminum Ore (Electro-reduction), Horizontal Stud Soderberg Cell
30300103 Aluminum Ore (Electro-reduction), Vertical Stud Soderberg Cell
30300104 Primary Metal Production, Aluminum Ore (Electro-reduction), Materials Handling
30300105 Primary Metal Production, Aluminum Ore (Electro-reduction), Anode Baking Furnace
30300106 Aluminum Ore (Electro-reduction), Degassing
30300107 Aluminum Ore (Electro-reduction), Roof Vents
30300108 Aluminum Ore (Electro-reduction), Prebake: Fugitive Emissions
30300109 Aluminum Ore (Electro-reduction), H.S.S.: Fugitive Emissions
30300110 Aluminum Ore (Electro-reduction), V.S.S.: Fugitive Emissions
30300199 Aluminum Ore (Electro-reduction), Not Classified **
30300201 Aluminum Hydroxide Calcining, Overall Process

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: PM10 control efficiency is 99% from uncontrolled; PM2.5 control efficiency is 95% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The following are cost ranges for wire-plate ESPs, developed using EPA cost-estimating spreadsheets for dry wire-plate ESPs with adjustments made to reflect wet wire-plate ESPs (EPA, 1999). Capital and operating costs are generally higher due to noncorrosive materials requirements, increased water usage, and treatment and disposal of wet effluent. When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used

AT-A-GLANCE TABLE FOR POINT SOURCES

(Pechan,2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 1990). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$30 to \$60 per scfm

Typical value is \$40 per scfm

O&M Costs:

Range from \$6 to \$45 per scfm

Typical value is \$19 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for ESP (EPA, 1999). O&M costs were calculated for three model plants with flow rates of 10, 15 and 20 thousand acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust loading of 6.0 grains per cubic feet. The operating time was assumed to be 8640 hours per year. A water flow rate for the ESP was assumed to be 5 gal/min per thousand acfm. The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.067	\$/kW-hr
Process water price	0.20	\$/1000 gal
Dust disposal	20	\$/ton disposed
Wastewater treatment	1.5	\$/ thousand gal treated

Note: All costs are in 1995 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$55 to \$550 per ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$220 per ton PM10 reduced. (1995\$)

Comments:

Status: Demonstrated

Last Reviewed: 2001

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

Costs can be substantially higher than in the ranges shown for pollutants which require an unusually high level of control, or which require the ESP to be constructed of special materials such as titanium (EPA, 1999). In most cases, smaller units controlling a low concentration waste stream will not be as cost effective as a large unit cleaning a high pollutant load flow (EPA, 1998).

In the wire-plate ESP, the gas flows around vertical, metal plates. The electrodes are long, weighted wires hanging between the plates. The voltage applied to the electrodes causes the gas between the electrodes to break down, known as a "corona." The electrodes are most often given a negative polarity because a negative corona supports a higher voltage than a positive corona.

Certain types of losses affect control efficiency. The dislodging of the accumulated layer also projects some of the particles back into the gas stream. These particles are processed in later sections of the ESP, but the particles from the last section have no chance to be recaptured. Due to the space needed at the top of the ESP for nonelectrified components, part of the stream may flow around the charged zones. This is called "sneakage" and places an upper limit on the collection efficiency of the ESP. Anti-sneakage baffles are used to force the sneakage flow to mix with the main gas stream for collection in later sections (EPA, 1998).

Wire-Plate Type Wet ESPs require a source of wash water near the top of the collector plates. This wash system replaces the rapping mechanism used by dry ESPs. The water flows with the collected particles into a sump from which the fluid is pumped or drained. A portion of the fluid may be recycled to reduce the total amount of water required. The remainder is pumped into a settling pond or passed through a dewatering stage, with subsequent disposal of the sludge (AWMA, 1992).

Unlike dry ESPs, resistivity of the collected material is not a major factor in performance. Because of the high humidity in a wet ESP, the resistivity of particles is lowered, eliminating the "back corona" condition. The frequent washing of the plates also limits particle buildup on the collectors (EPA, 1998).

For wet ESPs, the handling wastewaters must be considered (EPA, 1999). For simple systems with innocuous dusts, water with particles collected by the ESP may be discharged from the ESP system to a solids-removing clarifier. More complicated systems may require skimming and sludge removal, clarification in dedicated equipment, pH adjustment, and/or treatment to remove dissolved solids. Recirculation of treated water to the ESP may approach 100 percent (AWMA, 1992).

References:

AWMA, 1992: Air & Waste Management Association, Air Pollution Engineering Manual, Van Nostrand Reinhold, New York.

EPA, 1996: U.S. EPA, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, EPA 453/B-96-001, Research Triangle Park, NC. February.

EPA, 1998: U.S. EPA, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October.

EPA, 1999: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Wet Electrostatic Precipitator (ESP) - Wire-Plate Type," May 1999

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency,

AT-A-GLANCE TABLE FOR POINT SOURCES

Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Non-Ferrous Metals Processing - Aluminum

Control Measure Name: Fabric Filter (Reverse-Air Cleaned Type)

Rule Name: Not Applicable

Pechan Measure Code: P2114

POD: 211

Application: This control is the use of a reverse-air cleaned fabric filter to reduce PM emissions from waste streams. In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Reverse-air cleaning is performed by forcing clean air through the filters in the opposite direction of the dusty gas flow. The change in direction of the gas flow causes the bag to flex and crack the filter cake allowing for internal cake collection.

This control applies to aluminum processing and production operations.

Affected SCC:

30300001 Aluminum Ore (Bauxite), Crushing/Handling
30300002 Aluminum Ore (Bauxite), Drying Oven
30300003 Aluminum Ore (Bauxite), Fine Ore Storage
30300101 Primary Metal Production, Aluminum Ore (Electro-reduction), Prebaked Reduction Cell
30300102 Aluminum Ore (Electro-reduction), Horizontal Stud Soderberg Cell
30300103 Aluminum Ore (Electro-reduction), Vertical Stud Soderberg Cell
30300104 Primary Metal Production, Aluminum Ore (Electro-reduction), Materials Handling
30300105 Primary Metal Production, Aluminum Ore (Electro-reduction), Anode Baking Furnace
30300106 Aluminum Ore (Electro-reduction), Degassing
30300107 Aluminum Ore (Electro-reduction), Roof Vents
30300108 Aluminum Ore (Electro-reduction), Prebake: Fugitive Emissions
30300109 Aluminum Ore (Electro-reduction), H.S.S.: Fugitive Emissions
30300110 Aluminum Ore (Electro-reduction), V.S.S.: Fugitive Emissions
30300199 Aluminum Ore (Electro-reduction), Not Classified **
30300201 Aluminum Hydroxide Calcining, Overall Process

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 99% from uncontrolled for both PM10 and PM2.5

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs for reverse-air cleaned systems are generated using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan,2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and

AT-A-GLANCE TABLE FOR POINT SOURCES

administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 2000). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$9 to \$84 per scfm
Typical value is \$34 per scfm

O&M Costs:

Range from \$6 to \$27 per scfm
Typical value is \$13 per scfm

Note: All costs are in 1998 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$53 to \$337 per ton PM₁₀ removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$148 per ton PM₁₀ reduced. (1998\$)

Comments:

Status: Demonstrated	Last Reviewed: 2001
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Additional Information:

The cost estimates assume a conventional design under typical operating conditions. The costs do not include any auxiliary equipment (EPA, 2000).

The capital cost for the reverse-jet cleaned fabric baghouse is based on information provided by a manufacturer (EPA, 2000). The capital cost includes only the purchased equipment cost.

Costs are primarily based on volumetric flow rate and the amount of PM in the waste stream. In general, a small unit controlling a low pollutant levels will not be as cost effective as a large unit controlling a high pollutant levels. (EPA, 2000)

Pollutants requiring a high level of control or the fabric filters to be constructed of special materials will increase the costs of the system (EPA, 1998a). The additional costs for controlling complex streams are not reflected in the estimates. For these systems, the capital cost could increase by as much as 40% and the O&M cost could increase by as much as 5%. (EPA, 2000)

In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving

AT-A-GLANCE TABLE FOR POINT SOURCES

and other mechanisms. Fabric filters may be in the form of sheets, cartridges, or bags, with many individual filter units together in a group. Bags are the most common type of filter. The dust cake that forms on the filter from the collected PM can significantly increase collection efficiency. (EPA, 2000)

Reverse-air cleaning is a popular filter cleaning method as it has been used extensively and improved over the years. It is a gentler but sometimes less effective clearing mechanism than mechanical shaking. Reverse-air cleaning is performed by forcing clean air through the filters in the opposite direction of the dusty gas flow. The change in direction of the gas flow causes the bag to flex and crack the filter cake allowing for internal cake collection (EPA, 2000).

The most common design is to have separate compartments within the fabric filter so that each can be isolated and cleaned separately while the others continue to treat the dusty gas. There are several methods of reversing the flow through the filters. One method of providing the reverse flow is by the use of a fan or cleaned gas from other compartments. Reverse-air cleaning only used alone in cases where the dust releases easily from the fabric. In many instances, reverse-air is used along with shaking, pulsing or sonic horns (EPA, 1998b).

Fabric filters are useful for collecting particles with resistivities either too low or too high for collection with electrostatic precipitators. Fabric filters are useful in controlling particulate matter less than or equal to 10 micrometers (μm) in diameter (PM₁₀) and particulate matter less than or equal to 2.5 μm in diameter (PM_{2.5}). Fabric filters may be good candidates for collecting fly ash from low-sulfur coals or containing high unburned carbon levels and are relatively difficult to collect with electrostatic precipitators. (EPA, 2000)

References:

EPA, 1998b: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter, EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

EPA, 1998a: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, Chapter 5, EPA 453/B-96-001, Research Triangle Park, NC. December 1998.

EPA, 2000: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Fabric Filter - Reverse-Air Cleaned Type," April 2000.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Non-Ferrous Metals Processing - Aluminum

Control Measure Name: Increased Monitoring Frequency (IMF) of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P3211

POD: 211

Application: This measure is to conduct improved monitoring for PM_{2.5} emissions at stationary sources. Improved monitoring in this case means increasing the monitoring frequency of electrostatic precipitators, scrubbers, and fabric filters from once per day to four times per hour, with no change in monitoring technique.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (Barr and Schaffner) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

303000** Primary Metal Production, Aluminum Ore (Bauxite)

303001** Primary Metal Production, Aluminum Ore (Electro-reduction)

303002** Aluminum Hydroxide Calcining

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 6.5% for both PM₁₀ and PM_{2.5}

Equipment Life: Not applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs included the incremental record keeping and reporting associated with the increased monitoring frequency. Labor rates for 2003 were made that were obtained from the Bureau of Labor Statistics (labor rates include 140 percent overhead). The incremental costs included a one-time cost for development of the improved monitoring and recurring annual burden costs for incremental record keeping, reporting, and certification activities.

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$620 per ton PM reduced (2003\$).

Comments:

Status:

Last Reviewed: 2004

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM2.5 Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 2003.

BLS, 2003: Bureau of Labor Statistics, "Employer Costs for Employee Compensation – June 2003," Table 12, page 16, 2003.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Non-Ferrous Metals Processing - Aluminum

Control Measure Name: CEM Upgrade and Increased Monitoring Frequency of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P4211

POD: 211

Application: This measure examines the impacts of improving the PM monitoring technique at units currently using an ESP, scrubber, or fabric filter. In this improved technique scenario, the monitoring technique is upgraded to a PM continuous emission monitor. This improved monitoring technique also results in an increase to the monitoring frequency because a PM CEMS can make a measurement every 7.5 minutes. The monitoring frequency increases from once per day to eight times per hour.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (see References) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

303000** Primary Metal Production, Aluminum Ore (Bauxite)

303001** Primary Metal Production, Aluminum Ore (Electro-reduction)

303002** Aluminum Hydroxide Calcining

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 7.7% for both PM10 and PM2.5

Equipment Life: Unknown

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The total capital and annual operating costs for implementing an improved monitoring technique are calculated based on data from the EPA CEMS Cost Model and the PM CEMS Knowledge document. Labor rates in the EPA CEMS Cost Model are scaled to reflect 2003 labor rates (including 140 percent overhead) provided by the Bureau of Labor Statistics.

The cost effectiveness at a percent excess emission rate of 0.46 percent is \$5,200 per ton of PM2.5. This is based on a \$34 million capital investment cost, and a \$14 million total annualized cost when applied to 128 facilities.

AT-A-GLANCE TABLE FOR POINT SOURCES

Note: All costs are in 2003 dollars.

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$5,200 per ton PM reduced (2003\$).

Comments:

Status:

Last Reviewed: 2004

Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM_{2.5} Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 8, 2003.

EPA CEMS Cost Model, Version 3.0, U.S. Environmental Protection Agency.

EPA, 2000: U.S. Environmental Protection Agency, "Current Knowledge of Particulate Matter (PM) Continuous Emissions Monitoring," Chapter 9, PM CEMS Cost, September 8, 2000.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Non-Ferrous Metals Processing - Copper

Control Measure Name: Fabric Filter (Mech. Shaker Type)

Rule Name: Not Applicable

Pechan Measure Code: P2081

POD: 208

Application: This control is the addition of a mechanical shaker type fabric filter to reduce PM emissions. In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. The gas stream is drawn from beneath a cell plate in the floor and into the filter bags. The gas proceeds from the inside to the outside of the filter bags. The particles collect on the inside of the bags, forming a filter cake. In mechanical shaking units, the tops of bags are attached to a shaker bar, moved briskly to clean the bags.

This control applies to copper and copper alloy production operations.

Affected SCC:

30300502 Primary Copper Smelting, Multiple Hearth Roaster
30300503 Primary Copper Smelting, Reverberatory Smelting Furnace after Roaster
30300504 Primary Copper Smelting, Converter (All Configurations)
30300505 Primary Copper Smelting, Fire (Furnace) Refining
30300506 Primary Copper Smelting, Ore Concentrate Dryer
30300512 Primary Copper Smelting, Flash Smelting
30300515 Primary Copper Smelting, Converter: Fugitive Emissions
30300516 Primary Copper Smelting, Anode Refining Furnace: Fugitive Emissions
30300519 Primary Copper Smelting, Unpaved Road Traffic: Fugitive Emissions
30300522 Primary Copper Smelting, Slag Cleaning Furnace
30300527 Primary Copper Smelting, Dryer with Flash Furnace and Converter
30300534 Primary Copper Smelting, Flash Furnace After Concentrate Dryer
30300599 Primary Copper Smelting, Other Not Classified
30400208 Copper, Wire Burning: Incinerator
30400210 Copper, Charge with Scrap Copper: Cupolas
30400214 Copper, Charge with Copper: Reverberatory Furnace
30400215 Copper, Charge with Brass and Bronze: Reverberatory Furnace
30400217 Copper, Charge with Brass and Bronze: Rotary Furnace
30400219 Copper, Charge with Brass and Bronze: Crucible and Pot Furnace
30400220 Secondary Metal Production, Copper, Charge with Copper: Electric Arc Furnace
30400223 Copper, Charge with Copper: Electric Induction
30400224 Copper, Charge with Brass and Bronze: Electric Induction
30400231 Copper, Scrap Dryer
30400232 Copper, Wire Incinerator
30400235 Copper, Reverberatory Furnace
30400236 Copper, Rotary Furnace
30400239 Copper, Casting Operations
30400299 Secondary Metal Production, Copper, Other Not Classified

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 99% from uncontrolled for both PM10 and PM2.5

AT-A-GLANCE TABLE FOR POINT SOURCES

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs for mechanical shaker cleaned systems are generated using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan,2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 2000). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$8 to \$71 per scfm

Typical value is \$29 per scfm

O&M Costs:

Range from \$4 to \$24 per scfm

Typical value is \$11 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). O&M costs were calculated for three model plants with flow rates of 25, 75 and 150 thousand acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust loading of 4.0 grains per cubic feet. The operating time was assumed to be 8760 hours per year. An average bag cost was estimated using the costs for standard bag types. Capital recovery for the periodic replacement of bags was included in the O&M cost of the bags using a bag life of 2 years (EPA, 1998a). The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.0671	\$/kW-hr
Compressed air	0.25	\$/1000 scf

AT-A-GLANCE TABLE FOR POINT SOURCES

Dust disposal	25	\$/ton disposed
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Note: All costs are in 1998 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$37 to \$303 per ton PM₁₀ removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$126 per ton PM₁₀ reduced. (1998\$)

Comments:

Status: Demonstrated	Last Reviewed: 2001
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Additional Information:

Cost estimates assume a conventional design under typical operating conditions. The costs do not include auxiliary equipment such as fans and ductwork. (EPA, 2000)

Costs are primarily based on volumetric flow rate and the amount of PM in the waste stream. In general, a small unit controlling a low pollutant levels will not be as cost effective as a large unit controlling a high pollutant levels. (EPA, 2000)

Pollutants requiring a high level of control or the fabric filters to be constructed of special materials will increase the costs of the system (EPA, 1998a). The additional costs for controlling complex waste streams are not included in the estimates. For these systems, the capital cost could increase by as much as 30% and the O&M cost could increase by as much as 7%.

In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Fabric filters may be in the form of sheets, cartridges, or bags, with many individual filter units together in a group. Bags are the most common type of filter. The dust cake that forms on the filter from the collected PM can significantly increase collection efficiency. (EPA, 2000)

Mechanical shaking is a popular cleaning method because it is both simple and effective. In typical operation, dusty gas enters an inlet pipe to the fabric filter and very large particles are removed using a baffle plate fall into the hopper. The gas stream is drawn from beneath a cell plate in the floor and into the filter bags (EPA, 2000). The gas proceeds from the inside to the outside of the filter bags. The particles collect on the inside of the bags, forming a filter cake. In mechanical shaking units, the tops of bags are attached to a shaker bar, moved briskly (usually in a horizontal direction) to clean the bags. The shaker bars are operated by mechanical motors or by hand (EPA, 1998b)..

Fabric filters are useful for collecting particles with resistivities either too low or too high for collection with electrostatic precipitators. Fabric filters are useful in controlling particulate matter less than or equal to 10 micrometers (µm) in diameter (PM₁₀) and particulate matter less than or equal to 2.5 µm in diameter (PM_{2.5}). Fabric filters may be good candidates for collecting fly ash from low-sulfur coals or containing high unburned carbon levels and are relatively difficult to collect with electrostatic precipitators. (EPA, 2000)

References:

EPA, 1998a: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, Chapter 5, EPA 453/B-96-001, Research Triangle Park, NC. December 1998.

AT-A-GLANCE TABLE FOR POINT SOURCES

EPA, 1998b: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

EPA, 2000: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Fabric Filter - Mechanical Shaker Cleaned Type," August 2000.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Non-Ferrous Metals Processing - Copper

Control Measure Name: Dry ESP-Wire Plate Type

Rule Name: Not Applicable

Pechan Measure Code: P2082

POD: 208

Application: This control is the use of dry electrostatic precipitators (ESP) to reduce PM emissions. An ESP uses electrical forces to move particles in an exhaust stream onto collector plates. Electrodes in the center of the flow are maintained at high voltage and generate an electrical field forcing particles to the collector walls. In dry ESOPs, the collectors are knocked by various mechanical means to dislodge the particulate, which slides downward into a hopper.

This control applies to copper and copper-allow metal processing operations.

Affected SCC:

30300502 Primary Copper Smelting, Multiple Hearth Roaster
30300503 Primary Copper Smelting, Reverberatory Smelting Furnace after Roaster
30300504 Primary Copper Smelting, Converter (All Configurations)
30300505 Primary Copper Smelting, Fire (Furnace) Refining
30300506 Primary Copper Smelting, Ore Concentrate Dryer
30300512 Primary Copper Smelting, Flash Smelting
30300515 Primary Copper Smelting, Converter: Fugitive Emissions
30300516 Primary Copper Smelting, Anode Refining Furnace: Fugitive Emissions
30300519 Primary Copper Smelting, Unpaved Road Traffic: Fugitive Emissions
30300522 Primary Copper Smelting, Slag Cleaning Furnace
30300527 Primary Copper Smelting, Dryer with Flash Furnace and Converter
30300534 Primary Copper Smelting, Flash Furnace After Concentrate Dryer
30300599 Primary Copper Smelting, Other Not Classified
30400210 Copper, Charge with Scrap Copper: Cupolas
30400214 Copper, Charge with Copper: Reverberatory Furnace
30400215 Copper, Charge with Brass and Bronze: Reverberatory Furnace
30400217 Copper, Charge with Brass and Bronze: Rotary Furnace
30400219 Copper, Charge with Brass and Bronze: Crucible and Pot Furnace
30400223 Copper, Charge with Copper: Electric Induction
30400224 Copper, Charge with Brass and Bronze: Electric Induction
30400231 Copper, Scrap Dryer
30400232 Copper, Wire Incinerator
30400235 Copper, Reverberatory Furnace
30400236 Copper, Rotary Furnace
30400239 Copper, Casting Operations
30400299 Secondary Metal Production, Copper, Other Not Classified

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: PM10 control efficiency is 98% from uncontrolled; PM2.5 control efficiency is 95% from uncontrolled

Equipment Life: 20 years

AT-A-GLANCE TABLE FOR POINT SOURCES

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs for ESPs of conventional design under typical operating conditions are developed using EPA cost estimating spreadsheets (EPA, 1996). When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan, 2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 1999). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$15 to \$50 per scfm

Typical value is \$27 per scfm

O&M Costs:

Range from \$4 to \$40 per scfm

Typical value is \$16 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for ESP (EPA, 1996). O&M costs were calculated for three model plants with flow rates of 200 and 500 thousand acfm and 1 million acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust loading of 6.0 grains per cubic feet. The operating time was assumed to be 8640 hours per year. The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.067	\$/kW-hr
Dust disposal	25	\$/ton disposed

Note: All costs are in 1995 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$40 to \$250 per

AT-A-GLANCE TABLE FOR POINT SOURCES

ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$110 per ton PM10 reduced. (1995\$)

Comments:

Status: Demonstrated**Last Reviewed:** 2001

Additional Information:

In the wire-plate ESP, the gas flows around vertical, metal plates. The electrodes are long, weighted wires hanging between the plates. The voltage applied to the electrodes causes the gas between the electrodes to break down, known as a "corona." The electrodes are most often given a negative polarity because a negative corona supports a higher voltage than a positive corona.

Certain types of losses affect control efficiency. The dislodging of the accumulated layer also projects some of the particles back into the gas stream. These particles are processed in later sections of the ESP, but the particles from the last section have no chance to be recaptured. Due to the space needed at the top of the ESP for nonelectrified components, part of the stream may flow around the charged zones. This is called "sneakage" and places an upper limit on the collection efficiency of the ESP. Anti-sneakage baffles are used to force the sneakage flow to mix with the main gas stream for collection in later sections (EPA, 1998).

Another factor in the performance of ESPs is the resistivity of the collected material. All the ion current must pass through the collected layer to reach the ground plates. This creates an electric field in the layer, and it can become large enough to cause electrical breakdown. When this occurs, new ions of the wrong polarity are injected into the wire-plate gap reducing the charge on the particles, which may cause sparking. This condition is called "back corona." When this happens the collection ability of the unit is reduced. At low resistivities the particles are held on the plates so loosely that reentrainment levels are much higher. Hence, care must be taken in measuring or estimating resistivity because it is strongly affected by such variables as temperature, moisture, gas composition, particle composition, and surface characteristics (EPA, 1999).

Dusts with high resistivities are also not well-suited for collection in dry ESPs. These particles are not easily charged nor easily collected. High-resistivity particles form ash layers with very high voltage gradients on the collecting electrodes lead to back corona, reducing the charge on particles and lowering collection efficiency. Fly ash from the combustion of low-sulfur coal typically has a high resistivity, and thus is difficult to collect using dry ESPs (EPA, 1999).

References:

EPA, 1996: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, EPA 453/B-96-001, Research Triangle Park, NC. February 1996.

EPA, 1998: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

EPA, 1999: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Dry Electrostatic Precipitator (ESP) - Wire-Plate Type," May 1999.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Non-Ferrous Metals Processing - Copper

Control Measure Name: Wet ESP - Wire Plate Type

Rule Name: Not Applicable

Pechan Measure Code: P2083

POD: 208

Application: This control is the use of a wire-plate type electrostatic precipitator (ESP) to reduce PM emissions. An ESP uses electrical forces to move particles in an exhaust stream onto collector plates. Electrodes in the center of the flow are maintained at high voltage and generate an electrical field forcing particles to the collector walls. Wet ESPs use a stream of water, in place of rapping mechanisms, to dislodge particulate from the plates and into a sump.

This control applies to copper and copper alloy processing and production operations.

Affected SCC:

30300502 Primary Copper Smelting, Multiple Hearth Roaster
30300503 Primary Copper Smelting, Reverberatory Smelting Furnace after Roaster
30300504 Primary Copper Smelting, Converter (All Configurations)
30300505 Primary Copper Smelting, Fire (Furnace) Refining
30300506 Primary Copper Smelting, Ore Concentrate Dryer
30300512 Primary Copper Smelting, Flash Smelting
30300515 Primary Copper Smelting, Converter: Fugitive Emissions
30300516 Primary Copper Smelting, Anode Refining Furnace: Fugitive Emissions
30300519 Primary Copper Smelting, Unpaved Road Traffic: Fugitive Emissions
30300522 Primary Copper Smelting, Slag Cleaning Furnace
30300527 Primary Copper Smelting, Dryer with Flash Furnace and Converter
30300534 Primary Copper Smelting, Flash Furnace After Concentrate Dryer
30300599 Primary Copper Smelting, Other Not Classified
30400208 Copper, Wire Burning: Incinerator
30400210 Copper, Charge with Scrap Copper: Cupolas
30400214 Copper, Charge with Copper: Reverberatory Furnace
30400215 Copper, Charge with Brass and Bronze: Reverberatory Furnace
30400217 Copper, Charge with Brass and Bronze: Rotary Furnace
30400219 Copper, Charge with Brass and Bronze: Crucible and Pot Furnace
30400220 Secondary Metal Production, Copper, Charge with Copper: Electric Arc Furnace
30400223 Copper, Charge with Copper: Electric Induction
30400224 Copper, Charge with Brass and Bronze: Electric Induction
30400231 Copper, Scrap Dryer
30400232 Copper, Wire Incinerator
30400235 Copper, Reverberatory Furnace
30400236 Copper, Rotary Furnace
30400239 Copper, Casting Operations
30400299 Secondary Metal Production, Copper, Other Not Classified

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: PM10 control efficiency is 99% from uncontrolled; PM2.5 control efficiency is 95% from uncontrolled

AT-A-GLANCE TABLE FOR POINT SOURCES

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The following are cost ranges for wire-plate ESPs, developed using EPA cost-estimating spreadsheets for dry wire-plate ESPs with adjustments made to reflect wet wire-plate ESPs (EPA, 1999). Capital and operating costs are generally higher due to noncorrosive materials requirements, increased water usage, and treatment and disposal of wet effluent. When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM₁₀ removed were used (Pechan,2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 1990). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$30 to \$60 per scfm

Typical value is \$40 per scfm

O&M Costs:

Range from \$6 to \$45 per scfm

Typical value is \$19 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for ESP (EPA, 1999). O&M costs were calculated for three model plants with flow rates of 10, 15 and 20 thousand acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust loading of 6.0 grains per cubic feet. The operating time was assumed to be 8640 hours per year. A water flow rate for the ESP was assumed to be 5 gal/min per thousand acfm. The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.067	\$/kW-hr
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AT-A-GLANCE TABLE FOR POINT SOURCES

Process water price	0.20	\$/1000 gal
Dust disposal	20	\$/ton disposed
Wastewater treatment	1.5	\$/ thousand gal treated

Note: All costs are in 1995 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$55 to \$550 per ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$220 per ton PM10 reduced. (1995\$)

Comments:

Status: Demonstrated	Last Reviewed: 2001
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Additional Information:

Costs can be substantially higher than in the ranges shown for pollutants which require an unusually high level of control, or which require the ESP to be constructed of special materials such as titanium (EPA, 1999). In most cases, smaller units controlling a low concentration waste stream will not be as cost effective as a large unit cleaning a high pollutant load flow (EPA, 1998).

In the wire-plate ESP, the gas flows around vertical, metal plates. The electrodes are long, weighted wires hanging between the plates. The voltage applied to the electrodes causes the gas between the electrodes to break down, known as a "corona." The electrodes are most often given a negative polarity because a negative corona supports a higher voltage than a positive corona.

Certain types of losses affect control efficiency. The dislodging of the accumulated layer also projects some of the particles back into the gas stream. These particles are processed in later sections of the ESP, but the particles from the last section have no chance to be recaptured. Due to the space needed at the top of the ESP for nonelectrified components, part of the stream may flow around the charged zones. This is called "sneakage" and places an upper limit on the collection efficiency of the ESP. Anti-sneakage baffles are used to force the sneakage flow to mix with the main gas stream for collection in later sections (EPA, 1998).

Wire-Plate Type Wet ESPs require a source of wash water near the top of the collector plates. This wash system replaces the rapping mechanism used by dry ESPs. The water flows with the collected particles into a sump from which the fluid is pumped or drained. A portion of the fluid may be recycled to reduce the total amount of water required. The remainder is pumped into a settling pond or passed through a dewatering stage, with subsequent disposal of the sludge (AWMA, 1992).

Unlike dry ESPs, resistivity of the collected material is not a major factor in performance. Because of the high humidity in a wet ESP, the resistivity of particles is lowered, eliminating the "back corona" condition. The frequent washing of the plates also limits particle buildup on the collectors (EPA, 1998).

For wet ESPs, the handling wastewaters must be considered (EPA, 1999). For simple systems with innocuous dusts, water with particles collected by the ESP may be discharged from the ESP system to a solids-removing clarifier. More complicated systems may require skimming and sludge removal, clarification in dedicated equipment, pH adjustment, and/or treatment to remove dissolved solids. Recirculation of treated water to the ESP may approach 100 percent (AWMA, 1992).

AT-A-GLANCE TABLE FOR POINT SOURCES

References:

AWMA, 1992: Air & Waste Management Association, Air Pollution Engineering Manual, Van Nostrand Reinhold, New York.

EPA, 1996: U.S. EPA, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, EPA 453/B-96-001, Research Triangle Park, NC. February.

EPA, 1998: U.S. EPA, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October.

EPA, 1999: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Wet Electrostatic Precipitator (ESP) - Wire-Plate Type," May 1999

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Non-Ferrous Metals Processing - Copper

Control Measure Name: Fabric Filter (Reverse-Air Cleaned Type)

Rule Name: Not Applicable

Pechan Measure Code: P2084

POD: 208

Application: This control is the use of a reverse-air cleaned fabric filter to reduce PM emissions from waste streams. In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Reverse-air cleaning is performed by forcing clean air through the filters in the opposite direction of the dusty gas flow. The change in direction of the gas flow causes the bag to flex and crack the filter cake allowing for internal cake collection.

This control applies to copper and copper alloy production operations.

Affected SCC:

30300502 Primary Copper Smelting, Multiple Hearth Roaster
30300503 Primary Copper Smelting, Reverberatory Smelting Furnace after Roaster
30300504 Primary Copper Smelting, Converter (All Configurations)
30300505 Primary Copper Smelting, Fire (Furnace) Refining
30300506 Primary Copper Smelting, Ore Concentrate Dryer
30300512 Primary Copper Smelting, Flash Smelting
30300515 Primary Copper Smelting, Converter: Fugitive Emissions
30300516 Primary Copper Smelting, Anode Refining Furnace: Fugitive Emissions
30300519 Primary Copper Smelting, Unpaved Road Traffic: Fugitive Emissions
30300522 Primary Copper Smelting, Slag Cleaning Furnace
30300527 Primary Copper Smelting, Dryer with Flash Furnace and Converter
30300534 Primary Copper Smelting, Flash Furnace After Concentrate Dryer
30300599 Primary Copper Smelting, Other Not Classified
30400208 Copper, Wire Burning: Incinerator
30400210 Copper, Charge with Scrap Copper: Cupolas
30400214 Copper, Charge with Copper: Reverberatory Furnace
30400215 Copper, Charge with Brass and Bronze: Reverberatory Furnace
30400217 Copper, Charge with Brass and Bronze: Rotary Furnace
30400219 Copper, Charge with Brass and Bronze: Crucible and Pot Furnace
30400220 Secondary Metal Production, Copper, Charge with Copper: Electric Arc Furnace
30400223 Copper, Charge with Copper: Electric Induction
30400224 Copper, Charge with Brass and Bronze: Electric Induction
30400231 Copper, Scrap Dryer
30400232 Copper, Wire Incinerator
30400235 Copper, Reverberatory Furnace
30400236 Copper, Rotary Furnace
30400239 Copper, Casting Operations
30400299 Secondary Metal Production, Copper, Other Not Classified

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 99% from uncontrolled for both PM10 and PM2.5

AT-A-GLANCE TABLE FOR POINT SOURCES

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs for reverse-air cleaned systems are generated using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan,2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 2000). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$9 to \$84 per scfm

Typical value is \$34 per scfm

O&M Costs:

Range from \$6 to \$27 per scfm

Typical value is \$13 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). O&M costs were calculated for three model plants with flow rates of 25, 75 and 150 thousand acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust loading of 4.0 grains per cubic feet. The operating time was assumed to be 8760 hours per year. An average bag cost was estimated using the costs for standard bag types. Capital recovery for the periodic replacement of bags was included in the O&M cost of the bags using a bag life of 2 years (EPA, 1998a). The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.0671	\$/kW-hr
Compressed air	0.25	\$/1000 scf

AT-A-GLANCE TABLE FOR POINT SOURCES

Dust disposal	25	\$/ton disposed
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Note: All costs are in 1998 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$53 to \$337 per ton PM₁₀ removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$148 per ton PM₁₀ reduced. (1998\$)

Comments:

Status: Demonstrated	Last Reviewed: 2001
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Additional Information:

The cost estimates assume a conventional design under typical operating conditions. The costs do not include any auxiliary equipment (EPA, 2000).

The capital cost for the reverse-jet cleaned fabric baghouse is based on information provided by a manufacturer (EPA, 2000). The capital cost includes only the purchased equipment cost.

Costs are primarily based on volumetric flow rate and the amount of PM in the waste stream. In general, a small unit controlling a low pollutant levels will not be as cost effective as a large unit controlling a high pollutant levels. (EPA, 2000)

Pollutants requiring a high level of control or the fabric filters to be constructed of special materials will increase the costs of the system (EPA, 1998a). The additional costs for controlling complex streams are not reflected in the estimates. For these systems, the capital cost could increase by as much as 40% and the O&M cost could increase by as much as 5%. (EPA, 2000)

In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Fabric filters may be in the form of sheets, cartridges, or bags, with many individual filter units together in a group. Bags are the most common type of filter. The dust cake that forms on the filter from the collected PM can significantly increase collection efficiency. (EPA, 2000)

Reverse-air cleaning is a popular filter cleaning method as it has been used extensively and improved over the years. It is a gentler but sometimes less effective clearing mechanism than mechanical shaking. Reverse-air cleaning is performed by forcing clean air through the filters in the opposite direction of the dusty gas flow. The change in direction of the gas flow causes the bag to flex and crack the filter cake allowing for internal cake collection (EPA, 2000).

The most common design is to have separate compartments within the fabric filter so that each can be isolated and cleaned separately while the others continue to treat the dusty gas. There are several methods of reversing the flow through the filters. One method of providing the reverse flow is by the use of a fan or cleaned gas from other compartments. Reverse-air cleaning only used alone in cases where the dust releases easily from the fabric. In many instances, reverse-air is used along with shaking, pulsing or sonic horns (EPA, 1998b).

Fabric filters are useful for collecting particles with resistivities either too low or too high for collection with electrostatic precipitators. Fabric filters are useful in controlling particulate matter less than or equal to 10 micrometers (µm) in diameter (PM₁₀) and particulate matter less than or equal to 2.5 µm in diameter (PM_{2.5}). Fabric filters may be good candidates for collecting fly ash from low-sulfur coals or containing high unburned carbon levels and are relatively difficult to collect with electrostatic

AT-A-GLANCE TABLE FOR POINT SOURCES

precipitators. (EPA, 2000)

References:

EPA, 1998b: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter, EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

EPA, 1998a: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, Chapter 5, EPA 453/B-96-001, Research Triangle Park, NC. December 1998.

EPA, 2000: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Fabric Filter - Reverse-Air Cleaned Type," April 2000.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Non-Ferrous Metals Processing - Copper

Control Measure Name: Increased Monitoring Frequency (IMF) of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P3208

POD: 208

Application: This measure is to conduct improved monitoring for PM_{2.5} emissions at stationary sources. Improved monitoring in this case means increasing the monitoring frequency of electrostatic precipitators, scrubbers, and fabric filters from once per day to four times per hour, with no change in monitoring technique.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (Barr and Schaffner) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

303005** Primary Copper Smelting

304002** Copper, Wire Burning

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 6.5% for both PM₁₀ and PM_{2.5}

Equipment Life: Not applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs included the incremental record keeping and reporting associated with the increased monitoring frequency. Labor rates for 2003 were made that were obtained from the Bureau of Labor Statistics (labor rates include 140 percent overhead). The incremental costs included a one-time cost for development of the improved monitoring and recurring annual burden costs for incremental record keeping, reporting, and certification activities.

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$620 per ton PM reduced (2003\$).

Comments:

Status:

Last Reviewed: 2004

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM2.5 Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 2003.

BLS, 2003: Bureau of Labor Statistics, "Employer Costs for Employee Compensation – June 2003," Table 12, page 16, 2003.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Non-Ferrous Metals Processing - Copper

Control Measure Name: CEM Upgrade and Increased Monitoring Frequency of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P4208

POD: 208

Application: This measure examines the impacts of improving the PM monitoring technique at units currently using an ESP, scrubber, or fabric filter. In this improved technique scenario, the monitoring technique is upgraded to a PM continuous emission monitor. This improved monitoring technique also results in an increase to the monitoring frequency because a PM CEMS can make a measurement every 7.5 minutes. The monitoring frequency increases from once per day to eight times per hour.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (see References) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

303005** Primary Copper Smelting

304002** Copper, Wire Burning

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 7.7% for both PM10 and PM2.5

Equipment Life: Unknown

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The total capital and annual operating costs for implementing an improved monitoring technique are calculated based on data from the EPA CEMS Cost Model and the PM CEMS Knowledge document. Labor rates in the EPA CEMS Cost Model are scaled to reflect 2003 labor rates (including 140 percent overhead) provided by the Bureau of Labor Statistics.

The cost effectiveness at a percent excess emission rate of 0.46 percent is \$5,200 per ton of PM2.5. This is based on a \$34 million capital investment cost, and a \$14 million total annualized cost when applied to 128 facilities.

Note: All costs are in 2003 dollars.

AT-A-GLANCE TABLE FOR POINT SOURCES

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$5,200 per ton PM reduced (2003\$).

Comments:

Status:

Last Reviewed: 2004

Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM_{2.5} Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 8, 2003.

EPA CEMS Cost Model, Version 3.0, U.S. Environmental Protection Agency.

EPA, 2000: U.S. Environmental Protection Agency, "Current Knowledge of Particulate Matter (PM) Continuous Emissions Monitoring," Chapter 9, PM CEMS Cost, September 8, 2000.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Non-Ferrous Metals Processing - Lead

Control Measure Name: Fabric Filter (Mech. Shaker Type)

Rule Name: Not Applicable

Pechan Measure Code: P2091

POD: 209

Application: This control is the addition of a mechanical shaker type fabric filter to reduce PM emissions. In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. The gas stream is drawn from beneath a cell plate in the floor and into the filter bags. The gas proceeds from the inside to the outside of the filter bags. The particles collect on the inside of the bags, forming a filter cake. In mechanical shaking units, the tops of bags are attached to a shaker bar, moved briskly to clean the bags.

This control applies lead production operations.

Affected SCC:

30301002 Lead Production, Blast Furnace Operation
30301004 Lead Production, Ore Crushing
30301005 Lead Production, Materials Handling (Includes 11, 12, 13, 04, 14)
30301009 Lead Production, Lead Dressing
30301010 Lead Production, Raw Material Crushing and Grinding
30301012 Lead Production, Raw Material Storage Piles
30301013 Lead Production, Raw Material Transfer
30301017 Lead Production, Sinter Fines Return Handling
30301020 Lead Production, Blast Furnace Lead Pouring
30301022 Lead Production, Lead Refining/Silver Retort
30301024 Lead Production, Reverberatory or Kettle Softening
30301025 Lead Production, Sinter Machine Leakage
30301099 Lead Production, Other Not Classified
30400401 Lead, Pot Furnace
30400402 Lead, Reverberatory Furnace
30400403 Lead, Blast Furnace (Cupola)
30400413 Lead, Smelting Furnace: Fugitive Emissions
30400499 Lead, Other Not Classified

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 99% from uncontrolled for both PM10 and PM2.5

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs for mechanical shaker cleaned systems are generated using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10

AT-A-GLANCE TABLE FOR POINT SOURCES

removed were used (Pechan,2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 2000). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$8 to \$71 per scfm
Typical value is \$29 per scfm

O&M Costs:

Range from \$4 to \$24 per scfm
Typical value is \$11 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). O&M costs were calculated for three model plants with flow rates of 25, 75 and 150 thousand acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust loading of 4.0 grains per cubic feet. The operating time was assumed to be 8760 hours per year. An average bag cost was estimated using the costs for standard bag types. Capital recovery for the periodic replacement of bags was included in the O&M cost of the bags using a bag life of 2 years (EPA, 1998a). The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.0671	\$/kW-hr
Compressed air	0.25	\$/1000 scf
Dust disposal	25	\$/ton disposed

Note: All costs are in 1998 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$37 to \$303 per ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$126 per ton PM10 reduced. (1998\$)

Comments:

AT-A-GLANCE TABLE FOR POINT SOURCES

Status: Demonstrated	Last Reviewed: 2001
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Additional Information:

Cost estimates assume a conventional design under typical operating conditions. The costs do not include auxiliary equipment such as fans and ductwork. (EPA, 2000)

Costs are primarily based on volumetric flow rate and the amount of PM in the waste stream. In general, a small unit controlling a low pollutant levels will not be as cost effective as a large unit controlling a high pollutant levels. (EPA, 2000)

Pollutants requiring a high level of control or the fabric filters to be constructed of special materials will increase the costs of the system (EPA, 1998a). The additional costs for controlling complex waste streams are not included in the estimates. For these systems, the capital cost could increase by as much as 30% and the O&M cost could increase by as much as 7%.

In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Fabric filters may be in the form of sheets, cartridges, or bags, with many individual filter units together in a group. Bags are the most common type of filter. The dust cake that forms on the filter from the collected PM can significantly increase collection efficiency. (EPA, 2000)

Mechanical shaking is a popular cleaning method because it is both simple and effective. In typical operation, dusty gas enters an inlet pipe to the fabric filter and very large particles are removed using a baffle plate fall into the hopper. The gas stream is drawn from beneath a cell plate in the floor and into the filter bags (EPA, 2000). The gas proceeds from the inside to the outside of the filter bags. The particles collect on the inside of the bags, forming a filter cake. In mechanical shaking units, the tops of bags are attached to a shaker bar, moved briskly (usually in a horizontal direction) to clean the bags. The shaker bars are operated by mechanical motors or by hand (EPA, 1998b)..

Fabric filters are useful for collecting particles with resistivities either too low or too high for collection with electrostatic precipitators. Fabric filters are useful in controlling particulate matter less than or equal to 10 micrometers (μm) in diameter (PM10) and particulate matter less than or equal to 2.5 μm in diameter (PM2.5). Fabric filters may be good candidates for collecting fly ash from low-sulfur coals or containing high unburned carbon levels and are relatively difficult to collect with electrostatic precipitators. (EPA, 2000)

References:

EPA, 1998a: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, Chapter 5, EPA 453/B-96-001, Research Triangle Park, NC. December 1998.

EPA, 1998b: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

EPA, 2000: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Fabric Filter - Mechanical Shaker Cleaned Type," August 2000.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Non-Ferrous Metals Processing - Lead

Control Measure Name: Dry ESP-Wire Plate Type

Rule Name: Not Applicable

Pechan Measure Code: P2092

POD: 209

Application: This control is the use of dry electrostatic precipitators (ESP) to reduce PM emissions. An ESP uses electrical forces to move particles in an exhaust stream onto collector plates. Electrodes in the center of the flow are maintained at high voltage and generate an electrical field forcing particles to the collector walls. In dry ESPs, the collectors are knocked by various mechanical means to dislodge the particulate, which slides downward into a hopper.

This control applies to lead processing operations.

Affected SCC:

30301002 Lead Production, Blast Furnace Operation
30301004 Lead Production, Ore Crushing
30301005 Lead Production, Materials Handling (Includes 11, 12, 13, 04, 14)
30301009 Lead Production, Lead Dressing
30301012 Lead Production, Raw Material Storage Piles
30301013 Lead Production, Raw Material Transfer
30301017 Lead Production, Sinter Fines Return Handling
30301020 Lead Production, Blast Furnace Lead Pouring
30301022 Lead Production, Lead Refining/Silver Retort
30301024 Lead Production, Reverberatory or Kettle Softening
30301025 Lead Production, Sinter Machine Leakage
30301099 Lead Production, Other Not Classified
30400401 Lead, Pot Furnace
30400402 Lead, Reverberatory Furnace
30400403 Lead, Blast Furnace (Cupola)
30400413 Lead, Smelting Furnace: Fugitive Emissions
30400499 Lead, Other Not Classified

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: PM10 control efficiency is 98% from uncontrolled; PM2.5 control efficiency is 95% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs for ESPs of conventional design under typical operating conditions are developed using EPA cost estimating spreadsheets (EPA, 1996). When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan, 2001).

AT-A-GLANCE TABLE FOR POINT SOURCES

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 1999). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$15 to \$50 per scfm
Typical value is \$27 per scfm

O&M Costs:

Range from \$4 to \$40 per scfm
Typical value is \$16 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for ESP (EPA, 1996). O&M costs were calculated for three model plants with flow rates of 200 and 500 thousand acfm and 1 million acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust loading of 6.0 grains per cubic feet. The operating time was assumed to be 8640 hours per year. The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.067	\$/kW-hr
Dust disposal	25	\$/ton disposed

Note: All costs are in 1995 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$40 to \$250 per ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$110 per ton PM10 reduced. (1995\$)

Comments:

Status: Demonstrated	Last Reviewed: 2001
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AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

In the wire-plate ESP, the gas flows around vertical, metal plates. The electrodes are long, weighted wires hanging between the plates. The voltage applied to the electrodes causes the gas between the electrodes to break down, known as a "corona." The electrodes are most often given a negative polarity because a negative corona supports a higher voltage than a positive corona.

Certain types of losses affect control efficiency. The dislodging of the accumulated layer also projects some of the particles back into the gas stream. These particles are processed in later sections of the ESP, but the particles from the last section have no chance to be recaptured. Due to the space needed at the top of the ESP for nonelectrified components, part of the stream may flow around the charged zones. This is called "sneakage" and places an upper limit on the collection efficiency of the ESP. Anti-sneakage baffles are used to force the sneakage flow to mix with the main gas stream for collection in later sections (EPA, 1998).

Another factor in the performance of ESPs is the resistivity of the collected material. All the ion current must pass through the collected layer to reach the ground plates. This creates an electric field in the layer, and it can become large enough to cause electrical breakdown. When this occurs, new ions of the wrong polarity are injected into the wire-plate gap reducing the charge on the particles, which may cause sparking. This condition is called "back corona." When this happens the collection ability of the unit is reduced. At low resistivities the particles are held on the plates so loosely that reentrainment levels are much higher. Hence, care must be taken in measuring or estimating resistivity because it is strongly affected by such variables as temperature, moisture, gas composition, particle composition, and surface characteristics (EPA, 1999).

Dusts with high resistivities are also not well-suited for collection in dry ESPs. These particles are not easily charged nor easily collected. High-resistivity particles form ash layers with very high voltage gradients on the collecting electrodes lead to back corona, reducing the charge on particles and lowering collection efficiency. Fly ash from the combustion of low-sulfur coal typically has a high resistivity, and thus is difficult to collect using dry ESPs (EPA, 1999).

References:

EPA, 1996: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, EPA 453/B-96-001, Research Triangle Park, NC. February 1996.

EPA, 1998: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

EPA, 1999: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Dry Electrostatic Precipitator (ESP) - Wire-Plate Type," May 1999.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Non-Ferrous Metals Processing - Lead

Control Measure Name: Wet ESP - Wire Plate Type

Rule Name: Not Applicable

Pechan Measure Code: P2093

POD: 209

Application: This control is the use of a wire-plate type electrostatic precipitator (ESP) to reduce PM emissions. An ESP uses electrical forces to move particles in an exhaust stream onto collector plates. Electrodes in the center of the flow are maintained at high voltage and generate an electrical field forcing particles to the collector walls. Wet ESPs use a stream of water, in place of rapping mechanisms, to dislodge particulate from the plates and into a sump.

This control applies to lead processing and production operations.

Affected SCC:

30301002 Lead Production, Blast Furnace Operation
30301004 Lead Production, Ore Crushing
30301005 Lead Production, Materials Handling (Includes 11, 12, 13, 04, 14)
30301009 Lead Production, Lead Drossing
30301010 Lead Production, Raw Material Crushing and Grinding
30301012 Lead Production, Raw Material Storage Piles
30301013 Lead Production, Raw Material Transfer
30301017 Lead Production, Sinter Fines Return Handling
30301020 Lead Production, Blast Furnace Lead Pouring
30301022 Lead Production, Lead Refining/Silver Retort
30301024 Lead Production, Reverberatory or Kettle Softening
30301025 Lead Production, Sinter Machine Leakage
30301099 Lead Production, Other Not Classified
30400401 Lead, Pot Furnace
30400402 Lead, Reverberatory Furnace
30400403 Lead, Blast Furnace (Cupola)
30400413 Lead, Smelting Furnace: Fugitive Emissions
30400499 Lead, Other Not Classified

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: PM10 control efficiency is 99% from uncontrolled; PM2.5 control efficiency is 95% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The following are cost ranges for wire-plate ESPs, developed using EPA cost-estimating spreadsheets for dry wire-plate ESPs with adjustments made to reflect wet wire-plate ESPs (EPA, 1999). Capital and operating costs are generally higher due to noncorrosive materials requirements, increased water usage, and treatment and disposal of wet effluent. When stack gas flow rate data was available, the costs

AT-A-GLANCE TABLE FOR POINT SOURCES

and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan,2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 1990). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$30 to \$60 per scfm

Typical value is \$40 per scfm

O&M Costs:

Range from \$6 to \$45 per scfm

Typical value is \$19 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for ESP (EPA, 1999). O&M costs were calculated for three model plants with flow rates of 10, 15 and 20 thousand acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust loading of 6.0 grains per cubic feet. The operating time was assumed to be 8640 hours per year. A water flow rate for the ESP was assumed to be 5 gal/min per thousand acfm. The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.067	\$/kW-hr
Process water price	0.20	\$/1000 gal
Dust disposal	20	\$/ton disposed
Wastewater treatment	1.5	\$/ thousand gal treated

Note: All costs are in 1995 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$55 to \$550 per ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$220 per ton PM10 reduced. (1995\$)

AT-A-GLANCE TABLE FOR POINT SOURCES

Comments:**Status:** Demonstrated**Last Reviewed:** 2001

Additional Information:

Costs can be substantially higher than in the ranges shown for pollutants which require an unusually high level of control, or which require the ESP to be constructed of special materials such as titanium (EPA, 1999). In most cases, smaller units controlling a low concentration waste stream will not be as cost effective as a large unit cleaning a high pollutant load flow (EPA, 1998).

In the wire-plate ESP, the gas flows around vertical, metal plates. The electrodes are long, weighted wires hanging between the plates. The voltage applied to the electrodes causes the gas between the electrodes to break down, known as a "corona." The electrodes are most often given a negative polarity because a negative corona supports a higher voltage than a positive corona.

Certain types of losses affect control efficiency. The dislodging of the accumulated layer also projects some of the particles back into the gas stream. These particles are processed in later sections of the ESP, but the particles from the last section have no chance to be recaptured. Due to the space needed at the top of the ESP for nonelectrified components, part of the stream may flow around the charged zones. This is called "sneakage" and places an upper limit on the collection efficiency of the ESP. Anti-sneakage baffles are used to force the sneakage flow to mix with the main gas stream for collection in later sections (EPA, 1998).

Wire-Plate Type Wet ESPs require a source of wash water near the top of the collector plates. This wash system replaces the rapping mechanism used by dry ESPs. The water flows with the collected particles into a sump from which the fluid is pumped or drained. A portion of the fluid may be recycled to reduce the total amount of water required. The remainder is pumped into a settling pond or passed through a dewatering stage, with subsequent disposal of the sludge (AWMA, 1992).

Unlike dry ESPs, resistivity of the collected material is not a major factor in performance. Because of the high humidity in a wet ESP, the resistivity of particles is lowered, eliminating the "back corona" condition. The frequent washing of the plates also limits particle buildup on the collectors (EPA, 1998).

For wet ESPs, the handling wastewaters must be considered (EPA, 1999). For simple systems with innocuous dusts, water with particles collected by the ESP may be discharged from the ESP system to a solids-removing clarifier. More complicated systems may require skimming and sludge removal, clarification in dedicated equipment, pH adjustment, and/or treatment to remove dissolved solids. Recirculation of treated water to the ESP may approach 100 percent (AWMA, 1992).

References:

AWMA, 1992: Air & Waste Management Association, Air Pollution Engineering Manual, Van Nostrand Reinhold, New York.

EPA, 1996: U.S. EPA, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, EPA 453/B-96-001, Research Triangle Park, NC. February.

EPA, 1998: U.S. EPA, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October.

EPA, 1999: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Wet Electrostatic Precipitator (ESP) - Wire-Plate Type," May 1999

AT-A-GLANCE TABLE FOR POINT SOURCES

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Non-Ferrous Metals Processing - Lead

Control Measure Name: Fabric Filter (Reverse-Air Cleaned Type)

Rule Name: Not Applicable

Pechan Measure Code: P2094

POD: 209

Application: This control is the use of a reverse-air cleaned fabric filter to reduce PM emissions from waste streams. In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Reverse-air cleaning is performed by forcing clean air through the filters in the opposite direction of the dusty gas flow. The change in direction of the gas flow causes the bag to flex and crack the filter cake allowing for internal cake collection.

This control applies to lead processing and production applications.

Affected SCC:

30301002 Lead Production, Blast Furnace Operation
30301004 Lead Production, Ore Crushing
30301005 Lead Production, Materials Handling (Includes 11, 12, 13, 04, 14)
30301009 Lead Production, Lead Dressing
30301010 Lead Production, Raw Material Crushing and Grinding
30301012 Lead Production, Raw Material Storage Piles
30301013 Lead Production, Raw Material Transfer
30301017 Lead Production, Sinter Fines Return Handling
30301020 Lead Production, Blast Furnace Lead Pouring
30301022 Lead Production, Lead Refining/Silver Retort
30301024 Lead Production, Reverberatory or Kettle Softening
30301025 Lead Production, Sinter Machine Leakage
30301099 Lead Production, Other Not Classified
30400401 Lead, Pot Furnace
30400402 Lead, Reverberatory Furnace
30400403 Lead, Blast Furnace (Cupola)
30400413 Lead, Smelting Furnace: Fugitive Emissions
30400499 Lead, Other Not Classified

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 99% from uncontrolled for both PM10 and PM2.5

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs for reverse-air cleaned systems are generated using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan,2001).

AT-A-GLANCE TABLE FOR POINT SOURCES

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 2000). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$9 to \$84 per scfm
Typical value is \$34 per scfm

O&M Costs:

Range from \$6 to \$27 per scfm
Typical value is \$13 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). O&M costs were calculated for three model plants with flow rates of 25, 75 and 150 thousand acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust loading of 4.0 grains per cubic feet. The operating time was assumed to be 8760 hours per year. An average bag cost was estimated using the costs for standard bag types. Capital recovery for the periodic replacement of bags was included in the O&M cost of the bags using a bag life of 2 years (EPA, 1998a). The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.0671	\$/kW-hr
Compressed air	0.25	\$/1000 scf
Dust disposal	25	\$/ton disposed

Note: All costs are in 1998 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$53 to \$337 per ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$148 per ton PM10 reduced. (1998\$)

Comments:

Status: Demonstrated

Last Reviewed: 2001

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

The cost estimates assume a conventional design under typical operating conditions. The costs do not include any auxiliary equipment (EPA, 2000).

The capital cost for the reverse-jet cleaned fabric baghouse is based on information provided by a manufacturer (EPA, 2000). The capital cost includes only the purchased equipment cost.

Costs are primarily based on volumetric flow rate and the amount of PM in the waste stream. In general, a small unit controlling a low pollutant levels will not be as cost effective as a large unit controlling a high pollutant levels. (EPA, 2000)

Pollutants requiring a high level of control or the fabric filters to be constructed of special materials will increase the costs of the system (EPA, 1998a). The additional costs for controlling complex streams are not reflected in the estimates. For these systems, the capital cost could increase by as much as 40% and the O&M cost could increase by as much as 5%. (EPA, 2000)

In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Fabric filters may be in the form of sheets, cartridges, or bags, with many individual filter units together in a group. Bags are the most common type of filter. The dust cake that forms on the filter from the collected PM can significantly increase collection efficiency. (EPA, 2000)

Reverse-air cleaning is a popular filter cleaning method as it has been used extensively and improved over the years. It is a gentler but sometimes less effective clearing mechanism than mechanical shaking. Reverse-air cleaning is performed by forcing clean air through the filters in the opposite direction of the dusty gas flow. The change in direction of the gas flow causes the bag to flex and crack the filter cake allowing for internal cake collection (EPA, 2000).

The most common design is to have separate compartments within the fabric filter so that each can be isolated and cleaned separately while the others continue to treat the dusty gas. There are several methods of reversing the flow through the filters. One method of providing the reverse flow is by the use of a fan or cleaned gas from other compartments. Reverse-air cleaning only used alone in cases where the dust releases easily from the fabric. In many instances, reverse-air is used along with shaking, pulsing or sonic horns (EPA, 1998b).

Fabric filters are useful for collecting particles with resistivities either too low or too high for collection with electrostatic precipitators. Fabric filters are useful in controlling particulate matter less than or equal to 10 micrometers (μm) in diameter (PM₁₀) and particulate matter less than or equal to 2.5 μm in diameter (PM_{2.5}). Fabric filters may be good candidates for collecting fly ash from low-sulfur coals or containing high unburned carbon levels and are relatively difficult to collect with electrostatic precipitators. (EPA, 2000)

References:

EPA, 1998b: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

EPA, 1998a: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, Chapter 5, EPA 453/B-96-001, Research Triangle Park, NC. December 1998.

EPA, 2000: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution

AT-A-GLANCE TABLE FOR POINT SOURCES

Technology Fact Sheet - Fabric Filter - Reverse-Air Cleaned Type," April 2000.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Non-Ferrous Metals Processing - Lead

Control Measure Name: Increased Monitoring Frequency (IMF) of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P3209

POD: 209

Application: This measure is to conduct improved monitoring for PM_{2.5} emissions at stationary sources. Improved monitoring in this case means increasing the monitoring frequency of electrostatic precipitators, scrubbers, and fabric filters from once per day to four times per hour, with no change in monitoring technique.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (Barr and Schaffner) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

303010** Lead Production

304004** Zinc Production

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 6.5% for both PM₁₀ and PM_{2.5}

Equipment Life: Not applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs included the incremental record keeping and reporting associated with the increased monitoring frequency. Labor rates for 2003 were made that were obtained from the Bureau of Labor Statistics (labor rates include 140 percent overhead). The incremental costs included a one-time cost for development of the improved monitoring and recurring annual burden costs for incremental record keeping, reporting, and certification activities.

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$620 per ton PM reduced (2003\$).

Comments:

Status:	Last Reviewed: 2004
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AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM2.5 Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 2003.

BLS, 2003: Bureau of Labor Statistics, "Employer Costs for Employee Compensation – June 2003," Table 12, page 16, 2003.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Non-Ferrous Metals Processing - Lead

Control Measure Name: CEM Upgrade and Increased Monitoring Frequency of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P4209

POD: 209

Application: This measure examines the impacts of improving the PM monitoring technique at units currently using an ESP, scrubber, or fabric filter. In this improved technique scenario, the monitoring technique is upgraded to a PM continuous emission monitor. This improved monitoring technique also results in an increase to the monitoring frequency because a PM CEMS can make a measurement every 7.5 minutes. The monitoring frequency increases from once per day to eight times per hour.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (see References) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

303010** Primary Metal Production, Lead Production

304004** Primary Metal Production, Zinc Production

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 7.7% for both PM10 and PM2.5

Equipment Life: Unknown

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The total capital and annual operating costs for implementing an improved monitoring technique are calculated based on data from the EPA CEMS Cost Model and the PM CEMS Knowledge document. Labor rates in the EPA CEMS Cost Model are scaled to reflect 2003 labor rates (including 140 percent overhead) provided by the Bureau of Labor Statistics.

The cost effectiveness at a percent excess emission rate of 0.46 percent is \$5,200 per ton of PM2.5. This is based on a \$34 million capital investment cost, and a \$14 million total annualized cost when applied to 128 facilities.

Note: All costs are in 2003 dollars.

AT-A-GLANCE TABLE FOR POINT SOURCES

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$5,200 per ton PM reduced (2003\$).

Comments:

Status:

Last Reviewed: 2004

Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM_{2.5} Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 8, 2003.

EPA CEMS Cost Model, Version 3.0, U.S. Environmental Protection Agency.

EPA, 2000: U.S. Environmental Protection Agency, "Current Knowledge of Particulate Matter (PM) Continuous Emissions Monitoring," Chapter 9, PM CEMS Cost, September 8, 2000.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Non-Ferrous Metals Processing - Other

Control Measure Name: Fabric Filter (Mech. Shaker Type)

Rule Name: Not Applicable

Pechan Measure Code: P2121

POD: 212

Application: This control is the addition of a mechanical shaker type fabric filter to reduce PM emissions. In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. The gas stream is drawn from beneath a cell plate in the floor and into the filter bags. The gas proceeds from the inside to the outside of the filter bags. The particles collect on the inside of the bags, forming a filter cake. In mechanical shaking units, the tops of bags are attached to a shaker bar, moved briskly to clean the bags.

This control applies to miscellaneous non-ferrous metals processing operations, including molybdenum, titanium, gold, barium ore, lead battery, magnesium, nickel, electrode manufacture and metal heat treating operations.

Affected SCC:

30301102 Molybdenum, Milling: General
30301199 Molybdenum, Other Not Classified
30301201 Primary Metal Production, Titanium, Chlorination
30301202 Titanium, Drying Titanium Sand Ore (Cyclone Exit)
30301299 Titanium, Other Not Classified
30301301 Gold, General Processes
30301401 Barium Ore Processing, Ore Grinding
30301403 Barium Ore Processing, Dryers/Calciners
30301499 Barium Ore Processing, Other Not Classified
30400506 Lead Battery Manufacture, Grid Casting
30400507 Lead Battery Manufacture, Paste Mixing
30400512 Lead Battery Manufacture, Formation
30400523 Lead Battery Manufacture, Paste Mixing
30400525 Lead Battery Manufacture, Three Process Operation
30400650 Magnesium, American Magnesium Process
30400699 Magnesium, Other Not Classified
30401010 Nickel, Finishing: Pickling/Neutralizing
30401099 Nickel, Other Not Classified
30402001 Furnace Electrode Manufacture, Calcination
30402002 Furnace Electrode Manufacture, Mixing
30402004 Furnace Electrode Manufacture, Bake Furnaces
30402005 Furnace Electrode Manufacture, Grafitization of Coal by Heating Process
30402099 Furnace Electrode Manufacture, Other Not Classified
30402201 Metal Heat Treating, Furnace: General
30402211 Metal Heat Treating, Quenching

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 99% from uncontrolled for both PM10 and PM2.5

AT-A-GLANCE TABLE FOR POINT SOURCES

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs for mechanical shaker cleaned systems are generated using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan,2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 2000). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$8 to \$71 per scfm

Typical value is \$29 per scfm

O&M Costs:

Range from \$4 to \$24 per scfm

Typical value is \$11 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). O&M costs were calculated for three model plants with flow rates of 25, 75 and 150 thousand acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust loading of 4.0 grains per cubic feet. The operating time was assumed to be 8760 hours per year. An average bag cost was estimated using the costs for standard bag types. Capital recovery for the periodic replacement of bags was included in the O&M cost of the bags using a bag life of 2 years (EPA, 1998a). The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.0671	\$/kW-hr
Compressed air	0.25	\$/1000 scf

AT-A-GLANCE TABLE FOR POINT SOURCES

Dust disposal	25	\$/ton disposed
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Note: All costs are in 1998 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$37 to \$303 per ton PM₁₀ removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$126 per ton PM₁₀ reduced. (1998\$)

Comments:

Status: Demonstrated	Last Reviewed: 2001
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Additional Information:

Cost estimates assume a conventional design under typical operating conditions. The costs do not include auxiliary equipment such as fans and ductwork. (EPA, 2000)

Costs are primarily based on volumetric flow rate and the amount of PM in the waste stream. In general, a small unit controlling a low pollutant levels will not be as cost effective as a large unit controlling a high pollutant levels. (EPA, 2000)

Pollutants requiring a high level of control or the fabric filters to be constructed of special materials will increase the costs of the system (EPA, 1998a). The additional costs for controlling complex waste streams are not included in the estimates. For these systems, the capital cost could increase by as much as 30% and the O&M cost could increase by as much as 7%.

In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Fabric filters may be in the form of sheets, cartridges, or bags, with many individual filter units together in a group. Bags are the most common type of filter. The dust cake that forms on the filter from the collected PM can significantly increase collection efficiency. (EPA, 2000)

Mechanical shaking is a popular cleaning method because it is both simple and effective. In typical operation, dusty gas enters an inlet pipe to the fabric filter and very large particles are removed using a baffle plate fall into the hopper. The gas stream is drawn from beneath a cell plate in the floor and into the filter bags (EPA, 2000). The gas proceeds from the inside to the outside of the filter bags. The particles collect on the inside of the bags, forming a filter cake. In mechanical shaking units, the tops of bags are attached to a shaker bar, moved briskly (usually in a horizontal direction) to clean the bags. The shaker bars are operated by mechanical motors or by hand (EPA, 1998b).

Fabric filters are useful for collecting particles with resistivities either too low or too high for collection with electrostatic precipitators. Fabric filters are useful in controlling particulate matter less than or equal to 10 micrometers (μm) in diameter (PM₁₀) and particulate matter less than or equal to 2.5 μm in diameter (PM_{2.5}). Fabric filters may be good candidates for collecting fly ash from low-sulfur coals or containing high unburned carbon levels and are relatively difficult to collect with electrostatic precipitators. (EPA, 2000)

References:

EPA, 1998a: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, Chapter 5, EPA 453/B-96-001, Research Triangle Park, NC. December 1998.

AT-A-GLANCE TABLE FOR POINT SOURCES

EPA, 1998b: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

EPA, 2000: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Fabric Filter - Mechanical Shaker Cleaned Type," August 2000.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Non-Ferrous Metals Processing - Other

Control Measure Name: Dry ESP-Wire Plate Type

Rule Name: Not Applicable

Pechan Measure Code: P2122

POD: 212

Application: This control is the use of dry electrostatic precipitators (ESP) to reduce PM emissions. An ESP uses electrical forces to move particles in an exhaust stream onto collector plates. Electrodes in the center of the flow are maintained at high voltage and generate an electrical field forcing particles to the collector walls. In dry ESPs, the collectors are knocked by various mechanical means to dislodge the particulate, which slides downward into a hopper.

This control applies to miscellaneous non-ferrous metals processing operations, including molybdenum, titanium, gold, barium ore, lead battery, magnesium, nickel, electrode manufacture and metal heat treating operations.

Affected SCC:

30301102 Molybdenum, Milling: General
30301199 Molybdenum, Other Not Classified
30301201 Primary Metal Production, Titanium, Chlorination
30301202 Titanium, Drying Titanium Sand Ore (Cyclone Exit)
30301299 Titanium, Other Not Classified
30301301 Gold, General Processes
30301401 Barium Ore Processing, Ore Grinding
30301403 Barium Ore Processing, Dryers/Calciners
30301499 Barium Ore Processing, Other Not Classified
30400506 Lead Battery Manufacture, Grid Casting
30400512 Lead Battery Manufacture, Formation
30400525 Lead Battery Manufacture, Three Process Operation
30400650 Magnesium, American Magnesium Process
30400699 Magnesium, Other Not Classified
30401010 Nickel, Finishing: Pickling/Neutralizing
30401099 Nickel, Other Not Classified
30402001 Furnace Electrode Manufacture, Calcination
30402002 Furnace Electrode Manufacture, Mixing
30402004 Furnace Electrode Manufacture, Bake Furnaces
30402005 Furnace Electrode Manufacture, Graftitization of Coal by Heating Process
30402099 Furnace Electrode Manufacture, Other Not Classified
30402201 Metal Heat Treating, Furnace: General
30402211 Metal Heat Treating, Quenching

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: PM10 control efficiency is 98% from uncontrolled; PM2.5 control efficiency is 95% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

AT-A-GLANCE TABLE FOR POINT SOURCES

Penetration: 100%

Cost Basis: The costs for ESPs of conventional design under typical operating conditions are developed using EPA cost estimating spreadsheets (EPA, 1996). When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan, 2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 1999). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$15 to \$50 per scfm
Typical value is \$27 per scfm

O&M Costs:

Range from \$4 to \$40 per scfm
Typical value is \$16 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for ESP (EPA, 1996). O&M costs were calculated for three model plants with flow rates of 200 and 500 thousand acfm and 1 million acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust loading of 6.0 grains per cubic feet. The operating time was assumed to be 8640 hours per year. The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.067	\$/kW-hr
Dust disposal	25	\$/ton disposed

Note: All costs are in 1995 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$40 to \$250 per ton PM10 removed, depending on stack flow. The default cost effectiveness

AT-A-GLANCE TABLE FOR POINT SOURCES

value, used when stack flow is not available, is \$110 per ton PM10 reduced. (1995\$)

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

In the wire-plate ESP, the gas flows around vertical, metal plates. The electrodes are long, weighted wires hanging between the plates. The voltage applied to the electrodes causes the gas between the electrodes to break down, known as a "corona." The electrodes are most often given a negative polarity because a negative corona supports a higher voltage than a positive corona.

Certain types of losses affect control efficiency. The dislodging of the accumulated layer also projects some of the particles back into the gas stream. These particles are processed in later sections of the ESP, but the particles from the last section have no chance to be recaptured. Due to the space needed at the top of the ESP for nonelectrified components, part of the stream may flow around the charged zones. This is called "sneakage" and places an upper limit on the collection efficiency of the ESP. Anti-sneakage baffles are used to force the sneakage flow to mix with the main gas stream for collection in later sections (EPA, 1998).

Another factor in the performance of ESPs is the resistivity of the collected material. All the ion current must pass through the collected layer to reach the ground plates. This creates an electric field in the layer, and it can become large enough to cause electrical breakdown. When this occurs, new ions of the wrong polarity are injected into the wire-plate gap reducing the charge on the particles, which may cause sparking. This condition is called "back corona." When this happens the collection ability of the unit is reduced. At low resistivities the particles are held on the plates so loosely that reentrainment levels are much higher. Hence, care must be taken in measuring or estimating resistivity because it is strongly affected by such variables as temperature, moisture, gas composition, particle composition, and surface characteristics (EPA, 1999).

Dusts with high resistivities are also not well-suited for collection in dry ESPs. These particles are not easily charged nor easily collected. High-resistivity particles form ash layers with very high voltage gradients on the collecting electrodes lead to back corona, reducing the charge on particles and lowering collection efficiency. Fly ash from the combustion of low-sulfur coal typically has a high resistivity, and thus is difficult to collect using dry ESPs (EPA, 1999).

References:

EPA, 1996: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, EPA 453/B-96-001, Research Triangle Park, NC. February 1996.

EPA, 1998: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

EPA, 1999: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Dry Electrostatic Precipitator (ESP) - Wire-Plate Type," May 1999.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Non-Ferrous Metals Processing - Other

Control Measure Name: Wet ESP - Wire Plate Type

Rule Name: Not Applicable

Pechan Measure Code: P2123

POD: 212

Application: This control is the use of a wire-plate type electrostatic precipitator (ESP) to reduce PM emissions. An ESP uses electrical forces to move particles in an exhaust stream onto collector plates. Electrodes in the center of the flow are maintained at high voltage and generate an electrical field forcing particles to the collector walls. Wet ESPs use a stream of water, in place of rapping mechanisms, to dislodge particulate from the plates and into a sump.

This control applies to miscellaneous non-ferrous metals processing operations, including molybdenum, titanium, gold, barium ore, lead battery, magnesium, nickel, electrode manufacture and metal heat treating operations.

Affected SCC:

30301102 Molybdenum, Milling: General
30301199 Molybdenum, Other Not Classified
30301201 Primary Metal Production, Titanium, Chlorination
30301202 Titanium, Drying Titanium Sand Ore (Cyclone Exit)
30301299 Titanium, Other Not Classified
30301301 Gold, General Processes
30301401 Barium Ore Processing, Ore Grinding
30301403 Barium Ore Processing, Dryers/Calciners
30301499 Barium Ore Processing, Other Not Classified
30400506 Lead Battery Manufacture, Grid Casting
30400507 Lead Battery Manufacture, Paste Mixing
30400512 Lead Battery Manufacture, Formation
30400523 Lead Battery Manufacture, Paste Mixing
30400525 Lead Battery Manufacture, Three Process Operation
30400650 Magnesium, American Magnesium Process
30400699 Magnesium, Other Not Classified
30401010 Nickel, Finishing: Pickling/Neutralizing
30401099 Nickel, Other Not Classified
30402001 Furnace Electrode Manufacture, Calcination
30402002 Furnace Electrode Manufacture, Mixing
30402004 Furnace Electrode Manufacture, Bake Furnaces
30402005 Furnace Electrode Manufacture, Graftitization of Coal by Heating Process
30402099 Furnace Electrode Manufacture, Other Not Classified
30402201 Metal Heat Treating, Furnace: General
30402211 Metal Heat Treating, Quenching

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: PM10 control efficiency is 99% from uncontrolled; PM2.5 control efficiency is 95% from uncontrolled

Equipment Life: 20 years

AT-A-GLANCE TABLE FOR POINT SOURCES

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The following are cost ranges for wire-plate ESPs, developed using EPA cost-estimating spreadsheets for dry wire-plate ESPs with adjustments made to reflect wet wire-plate ESPs (EPA, 1999). Capital and operating costs are generally higher due to noncorrosive materials requirements, increased water usage, and treatment and disposal of wet effluent. When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan,2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 1990). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$30 to \$60 per scfm

Typical value is \$40 per scfm

O&M Costs:

Range from \$6 to \$45 per scfm

Typical value is \$19 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for ESP (EPA, 1999). O&M costs were calculated for three model plants with flow rates of 10, 15 and 20 thousand acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust loading of 6.0 grains per cubic feet. The operating time was assumed to be 8640 hours per year. A water flow rate for the ESP was assumed to be 5 gal/min per thousand acfm. The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.067	\$/kW-hr
Process water price	0.20	\$/1000 gal

AT-A-GLANCE TABLE FOR POINT SOURCES

Dust disposal	20	\$/ton disposed
Wastewater treatment	1.5	\$/ thousand gal treated

Note: All costs are in 1995 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$55 to \$550 per ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$220 per ton PM10 reduced. (1995\$)

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

Costs can be substantially higher than in the ranges shown for pollutants which require an unusually high level of control, or which require the ESP to be constructed of special materials such as titanium (EPA, 1999). In most cases, smaller units controlling a low concentration waste stream will not be as cost effective as a large unit cleaning a high pollutant load flow (EPA, 1998).

In the wire-plate ESP, the gas flows around vertical, metal plates. The electrodes are long, weighted wires hanging between the plates. The voltage applied to the electrodes causes the gas between the electrodes to break down, known as a "corona." The electrodes are most often given a negative polarity because a negative corona supports a higher voltage than a positive corona.

Certain types of losses affect control efficiency. The dislodging of the accumulated layer also projects some of the particles back into the gas stream. These particles are processed in later sections of the ESP, but the particles from the last section have no chance to be recaptured. Due to the space needed at the top of the ESP for nonelectrified components, part of the stream may flow around the charged zones. This is called "sneakage" and places an upper limit on the collection efficiency of the ESP. Anti-sneakage baffles are used to force the sneakage flow to mix with the main gas stream for collection in later sections (EPA, 1998).

Wire-Plate Type Wet ESPs require a source of wash water near the top of the collector plates. This wash system replaces the rapping mechanism used by dry ESPs. The water flows with the collected particles into a sump from which the fluid is pumped or drained. A portion of the fluid may be recycled to reduce the total amount of water required. The remainder is pumped into a settling pond or passed through a dewatering stage, with subsequent disposal of the sludge (AWMA, 1992).

Unlike dry ESPs, resistivity of the collected material is not a major factor in performance. Because of the high humidity in a wet ESP, the resistivity of particles is lowered, eliminating the "back corona" condition. The frequent washing of the plates also limits particle buildup on the collectors (EPA, 1998).

For wet ESPs, the handling wastewaters must be considered (EPA, 1999). For simple systems with innocuous dusts, water with particles collected by the ESP may be discharged from the ESP system to a solids-removing clarifier. More complicated systems may require skimming and sludge removal, clarification in dedicated equipment, pH adjustment, and/or treatment to remove dissolved solids. Recirculation of treated water to the ESP may approach 100 percent (AWMA, 1992).

AT-A-GLANCE TABLE FOR POINT SOURCES

References:

AWMA, 1992: Air & Waste Management Association, Air Pollution Engineering Manual, Van Nostrand Reinhold, New York.

EPA, 1996: U.S. EPA, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, EPA 453/B-96-001, Research Triangle Park, NC. February.

EPA, 1998: U.S. EPA, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October.

EPA, 1999: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Wet Electrostatic Precipitator (ESP) - Wire-Plate Type," May 1999

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Non-Ferrous Metals Processing - Other

Control Measure Name: Fabric Filter (Reverse-Air Cleaned Type)

Rule Name: Not Applicable

Pechan Measure Code: P2124

POD: 212

Application: This control is the use of a reverse-air cleaned fabric filter to reduce PM emissions from waste streams. In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Reverse-air cleaning is performed by forcing clean air through the filters in the opposite direction of the dusty gas flow. The change in direction of the gas flow causes the bag to flex and crack the filter cake allowing for internal cake collection.

This control applies to miscellaneous non-ferrous metals processing operations, including molybdenum, titanium, gold, barium ore, lead battery, magnesium, nickel, electrode manufacture and metal heat treating operations.

Affected SCC:

30301102 Molybdenum, Milling: General
30301199 Molybdenum, Other Not Classified
30301201 Primary Metal Production, Titanium, Chlorination
30301202 Titanium, Drying Titanium Sand Ore (Cyclone Exit)
30301299 Titanium, Other Not Classified
30301301 Gold, General Processes
30301401 Barium Ore Processing, Ore Grinding
30301403 Barium Ore Processing, Dryers/Calciners
30301499 Barium Ore Processing, Other Not Classified
30400506 Lead Battery Manufacture, Grid Casting
30400507 Lead Battery Manufacture, Paste Mixing
30400512 Lead Battery Manufacture, Formation
30400523 Lead Battery Manufacture, Paste Mixing
30400525 Lead Battery Manufacture, Three Process Operation
30400650 Magnesium, American Magnesium Process
30400699 Magnesium, Other Not Classified
30401010 Nickel, Finishing: Pickling/Neutralizing
30401099 Nickel, Other Not Classified
30402001 Furnace Electrode Manufacture, Calcination
30402002 Furnace Electrode Manufacture, Mixing
30402004 Furnace Electrode Manufacture, Bake Furnaces
30402005 Furnace Electrode Manufacture, Grafitization of Coal by Heating Process
30402099 Furnace Electrode Manufacture, Other Not Classified
30402201 Metal Heat Treating, Furnace: General
30402211 Metal Heat Treating, Quenching

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 99% from uncontrolled for both PM10 and PM2.5

Equipment Life: 20 years

AT-A-GLANCE TABLE FOR POINT SOURCES

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs for reverse-air cleaned systems are generated using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan,2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 2000). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$9 to \$84 per scfm
Typical value is \$34 per scfm

O&M Costs:

Range from \$6 to \$27 per scfm
Typical value is \$13 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). O&M costs were calculated for three model plants with flow rates of 25, 75 and 150 thousand acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust loading of 4.0 grains per cubic feet. The operating time was assumed to be 8760 hours per year. An average bag cost was estimated using the costs for standard bag types. Capital recovery for the periodic replacement of bags was included in the O&M cost of the bags using a bag life of 2 years (EPA, 1998a). The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.0671	\$/kW-hr
Compressed air	0.25	\$/1000 scf
Dust disposal	25	\$/ton disposed

AT-A-GLANCE TABLE FOR POINT SOURCES

Note: All costs are in 1998 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$53 to \$337 per ton PM₁₀ removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$148 per ton PM₁₀ reduced. (1998\$)

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

The cost estimates assume a conventional design under typical operating conditions. The costs do not include any auxiliary equipment (EPA, 2000).

The capital cost for the reverse-jet cleaned fabric baghouse is based on information provided by a manufacturer (EPA, 2000). The capital cost includes only the purchased equipment cost.

Costs are primarily based on volumetric flow rate and the amount of PM in the waste stream. In general, a small unit controlling a low pollutant levels will not be as cost effective as a large unit controlling a high pollutant levels. (EPA, 2000)

Pollutants requiring a high level of control or the fabric filters to be constructed of special materials will increase the costs of the system (EPA, 1998a). The additional costs for controlling complex streams are not reflected in the estimates. For these systems, the capital cost could increase by as much as 40% and the O&M cost could increase by as much as 5%. (EPA, 2000)

In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Fabric filters may be in the form of sheets, cartridges, or bags, with many individual filter units together in a group. Bags are the most common type of filter. The dust cake that forms on the filter from the collected PM can significantly increase collection efficiency. (EPA, 2000)

Reverse-air cleaning is a popular filter cleaning method as it has been used extensively and improved over the years. It is a gentler but sometimes less effective clearing mechanism than mechanical shaking. Reverse-air cleaning is performed by forcing clean air through the filters in the opposite direction of the dusty gas flow. The change in direction of the gas flow causes the bag to flex and crack the filter cake allowing for internal cake collection (EPA, 2000).

The most common design is to have separate compartments within the fabric filter so that each can be isolated and cleaned separately while the others continue to treat the dusty gas. There are several methods of reversing the flow through the filters. One method of providing the reverse flow is by the use of a fan or cleaned gas from other compartments. Reverse-air cleaning only used alone in cases where the dust releases easily from the fabric. In many instances, reverse-air is used along with shaking, pulsing or sonic horns (EPA, 1998b).

Fabric filters are useful for collecting particles with resistivities either too low or too high for collection with electrostatic precipitators. Fabric filters are useful in controlling particulate matter less than or equal to 10 micrometers (µm) in diameter (PM₁₀) and particulate matter less than or equal to 2.5 µm in diameter (PM_{2.5}). Fabric filters may be good candidates for collecting fly ash from low-sulfur coals or containing high unburned carbon levels and are relatively difficult to collect with electrostatic precipitators. (EPA, 2000)

AT-A-GLANCE TABLE FOR POINT SOURCES

References:

EPA, 1998b: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter, EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

EPA, 1998a: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, Chapter 5, EPA 453/B-96-001, Research Triangle Park, NC. December 1998.

EPA, 2000: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Fabric Filter - Reverse-Air Cleaned Type," April 2000.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Non-Ferrous Metals Processing - Other

Control Measure Name: Increased Monitoring Frequency (IMF) of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P3212

POD: 212

Application: This measure is to conduct improved monitoring for PM_{2.5} emissions at stationary sources. Improved monitoring in this case means increasing the monitoring frequency of electrostatic precipitators, scrubbers, and fabric filters from once per day to four times per hour, with no change in monitoring technique.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (Barr and Schaffner) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

304010** Nickel, Finishing
303888** Primary Metal Production, Fugitive Emissions
303014** Primary Metal Production, Barium Ore Processing
303013** Primary Metal Production, Gold
303012** Primary Metal Production, Titanium
303011** Primary Metal Production, Molybdenum
303999** Primary Metal Production, Other Not Classified
304001** Secondary Metal Production, Aluminum
303900** Primary Metal Production, Fuel Fired Equipment
304006** Secondary Metal Production, Magnesium
304020** Secondary Metal Production, Furnace Electrode Manufacture
304022** Secondary Metal Production, Metal Heat Treating
304050** Secondary Metal Production, Miscellaneous Casting and Fabricating
304888** Secondary Metal Production, Fugitive emission
304900** Secondary Metal Production, Fuel Fired equipment
304999** Secondary Metal Production, Other Not Classified
304005** Secondary Metal Production, Lead Battery Manufacture

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 6.5% for both PM₁₀ and PM_{2.5}

Equipment Life: Not applicable

Rule Effectiveness: 100%

AT-A-GLANCE TABLE FOR POINT SOURCES

Penetration: 100%

Cost Basis: The costs included the incremental record keeping and reporting associated with the increased monitoring frequency. Labor rates for 2003 were made that were obtained from the Bureau of Labor Statistics (labor rates include 140 percent overhead). The incremental costs included a one-time cost for development of the improved monitoring and recurring annual burden costs for incremental record keeping, reporting, and certification activities.

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$620 per ton PM reduced (2003\$).

Comments:

Status:

Last Reviewed: 2004

Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM2.5 Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 2003.

BLS, 2003: Bureau of Labor Statistics, "Employer Costs for Employee Compensation – June 2003," Table 12, page 16, 2003.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Non-Ferrous Metals Processing - Other

Control Measure Name: CEM Upgrade and Increased Monitoring Frequency of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P4212

POD: 212

Application: This measure examines the impacts of improving the PM monitoring technique at units currently using an ESP, scrubber, or fabric filter. In this improved technique scenario, the monitoring technique is upgraded to a PM continuous emission monitor. This improved monitoring technique also results in an increase to the monitoring frequency because a PM CEMS can make a measurement every 7.5 minutes. The monitoring frequency increases from once per day to eight times per hour.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (see References) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

304010** Nickel, Finishing
303888** Primary Metal Production, Fugitive Emissions
303014** Primary Metal Production, Barium Ore Processing
303013** Primary Metal Production, Gold
303012** Primary Metal Production, Titanium
303011** Primary Metal Production, Molybdenum
303999** Primary Metal Production, Other Not Classified
304001** Secondary Metal Production, Aluminum
303900** Primary Metal Production, Fuel Fired Equipment
304006** Secondary Metal Production, Magnesium
304020** Secondary Metal Production, Furnace Electrode Manufacture
304022** Secondary Metal Production, Metal Heat Treating
304050** Secondary Metal Production, Miscellaneous Casting and Fabricating
304888** Secondary Metal Production, Fugitive emission
304900** Secondary Metal Production, Fuel Fired equipment
304999** Secondary Metal Production, Other Not Classified
304005** Secondary Metal Production, Lead Battery Manufacture

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 7.7% for both PM10 and PM2.5

AT-A-GLANCE TABLE FOR POINT SOURCES

Equipment Life: Unknown

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The total capital and annual operating costs for implementing an improved monitoring technique are calculated based on data from the EPA CEMS Cost Model and the PM CEMS Knowledge document. Labor rates in the EPA CEMS Cost Model are scaled to reflect 2003 labor rates (including 140 percent overhead) provided by the Bureau of Labor Statistics.

The cost effectiveness at a percent excess emission rate of 0.46 percent is \$5,200 per ton of PM_{2.5}. This is based on a \$34 million capital investment cost, and a \$14 million total annualized cost when applied to 128 facilities.

Note: All costs are in 2003 dollars.

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$5,200 per ton PM reduced (2003\$).

Comments:

Status:

Last Reviewed: 2004

Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM_{2.5} Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 8, 2003.

EPA CEMS Cost Model, Version 3.0, U.S. Environmental Protection Agency.

EPA, 2000: U.S. Environmental Protection Agency, "Current Knowledge of Particulate Matter (PM) Continuous Emissions Monitoring," Chapter 9, PM CEMS Cost, September 8, 2000.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Non-Ferrous Metals Processing - Zinc

Control Measure Name: Fabric Filter (Mech. Shaker Type)

Rule Name: Not Applicable

Pechan Measure Code: P2101

POD: 210

Application: This control is the addition of a mechanical shaker type fabric filter to reduce PM emissions. In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. The gas stream is drawn from beneath a cell plate in the floor and into the filter bags. The gas proceeds from the inside to the outside of the filter bags. The particles collect on the inside of the bags, forming a filter cake. In mechanical shaking units, the tops of bags are attached to a shaker bar, moved briskly to clean the bags.

This control applies to zinc production and processing operations.

Affected SCC:

30303002 Zinc Production, Multiple Hearth Roaster
30303003 Zinc Production, Sinter Strand
30303005 Zinc Production, Vertical Retort/Electrothermal Furnace
30303006 Zinc Production, Electrolytic Processor
30303009 Zinc Production, Raw Material Handling and Transfer
30400801 Zinc, Retort Furnace
30400802 Zinc, Horizontal Muffle Furnace
30400803 Zinc, Pot Furnace
30400805 Zinc, Galvanizing Kettle
30400812 Zinc, Crushing/Screening of Zinc Residues
30400855 Zinc, Muffle Distillation/Oxidation
30400899 Zinc, Other Not Classified

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 99% from uncontrolled for both PM10 and PM2.5

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs for mechanical shaker cleaned systems are generated using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan,2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 2000). Total

AT-A-GLANCE TABLE FOR POINT SOURCES

installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$8 to \$71 per scfm
Typical value is \$29 per scfm

O&M Costs:

Range from \$4 to \$24 per scfm
Typical value is \$11 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). O&M costs were calculated for three model plants with flow rates of 25, 75 and 150 thousand acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust loading of 4.0 grains per cubic feet. The operating time was assumed to be 8760 hours per year. An average bag cost was estimated using the costs for standard bag types. Capital recovery for the periodic replacement of bags was included in the O&M cost of the bags using a bag life of 2 years (EPA, 1998a). The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.0671	\$/kW-hr
Compressed air	0.25	\$/1000 scf
Dust disposal	25	\$/ton disposed

Note: All costs are in 1998 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$37 to \$303 per ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$126 per ton PM10 reduced. (1998\$)

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

Cost estimates assume a conventional design under typical operating conditions. The costs do not include auxiliary equipment such as fans and ductwork. (EPA, 2000)

AT-A-GLANCE TABLE FOR POINT SOURCES

Costs are primarily based on volumetric flow rate and the amount of PM in the waste stream. In general, a small unit controlling a low pollutant levels will not be as cost effective as a large unit controlling a high pollutant levels. (EPA, 2000)

Pollutants requiring a high level of control or the fabric filters to be constructed of special materials will increase the costs of the system (EPA, 1998a). The additional costs for controlling complex waste streams are not included in the estimates. For these systems, the capital cost could increase by as much as 30% and the O&M cost could increase by as much as 7%.

In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Fabric filters may be in the form of sheets, cartridges, or bags, with many individual filter units together in a group. Bags are the most common type of filter. The dust cake that forms on the filter from the collected PM can significantly increase collection efficiency. (EPA, 2000)

Mechanical shaking is a popular cleaning method because it is both simple and effective. In typical operation, dusty gas enters an inlet pipe to the fabric filter and very large particles are removed using a baffle plate fall into the hopper. The gas stream is drawn from beneath a cell plate in the floor and into the filter bags (EPA, 2000). The gas proceeds from the inside to the outside of the filter bags. The particles collect on the inside of the bags, forming a filter cake. In mechanical shaking units, the tops of bags are attached to a shaker bar, moved briskly (usually in a horizontal direction) to clean the bags. The shaker bars are operated by mechanical motors or by hand (EPA, 1998b)..

Fabric filters are useful for collecting particles with resistivities either too low or too high for collection with electrostatic precipitators. Fabric filters are useful in controlling particulate matter less than or equal to 10 micrometers (μm) in diameter (PM₁₀) and particulate matter less than or equal to 2.5 μm in diameter (PM_{2.5}). Fabric filters may be good candidates for collecting fly ash from low-sulfur coals or containing high unburned carbon levels and are relatively difficult to collect with electrostatic precipitators. (EPA, 2000)

References:

EPA, 1998a: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, Chapter 5, EPA 453/B-96-001, Research Triangle Park, NC. December 1998.

EPA, 1998b: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

EPA, 2000: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Fabric Filter - Mechanical Shaker Cleaned Type," August 2000.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Non-Ferrous Metals Processing - Zinc

Control Measure Name: Dry ESP-Wire Plate Type

Rule Name: Not Applicable

Pechan Measure Code: P2102

POD: 210

Application: This control is the use of dry electrostatic precipitators (ESP) to reduce PM emissions. An ESP uses electrical forces to move particles in an exhaust stream onto collector plates. Electrodes in the center of the flow are maintained at high voltage and generate an electrical field forcing particles to the collector walls. In dry ESPs, the collectors are knocked by various mechanical means to dislodge the particulate, which slides downward into a hopper.

This control applies to zinc processing operations.

Affected SCC:

30303002 Zinc Production, Multiple Hearth Roaster
30303003 Zinc Production, Sinter Strand
30303005 Zinc Production, Vertical Retort/Electrothermal Furnace
30303006 Zinc Production, Electrolytic Processor
30400801 Zinc, Retort Furnace
30400802 Zinc, Horizontal Muffle Furnace
30400803 Zinc, Pot Furnace
30400805 Zinc, Galvanizing Kettle
30400855 Zinc, Muffle Distillation/Oxidation
30400899 Zinc, Other Not Classified

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: PM10 control efficiency is 98% from uncontrolled; PM2.5 control efficiency is 95% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs for ESPs of conventional design under typical operating conditions are developed using EPA cost estimating spreadsheets (EPA, 1996). When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan, 2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 1999). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years)

AT-A-GLANCE TABLE FOR POINT SOURCES

(Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$15 to \$50 per scfm
Typical value is \$27 per scfm

O&M Costs:

Range from \$4 to \$40 per scfm
Typical value is \$16 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for ESP (EPA, 1996). O&M costs were calculated for three model plants with flow rates of 200 and 500 thousand acfm and 1 million acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust loading of 6.0 grains per cubic feet. The operating time was assumed to be 8640 hours per year. The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.067	\$/kW-hr
Dust disposal	25	\$/ton disposed

Note: All costs are in 1995 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$40 to \$250 per ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$110 per ton PM10 reduced. (1995\$)

Comments:

Status: Demonstrated	Last Reviewed: 2001
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Additional Information:

In the wire-plate ESP, the gas flows around vertical, metal plates. The electrodes are long, weighted wires hanging between the plates. The voltage applied to the electrodes causes the gas between the electrodes to break down, known as a "corona." The electrodes are most often given a negative polarity because a negative corona supports a higher voltage than a positive corona.

Certain types of losses affect control efficiency. The dislodging of the accumulated layer also projects some of the particles back into the gas stream. These particles are processed in later sections of the ESP, but the particles from the last section have no chance to be recaptured. Due to

AT-A-GLANCE TABLE FOR POINT SOURCES

the space needed at the top of the ESP for nonelectrified components, part of the stream may flow around the charged zones. This is called "sneakage" and places an upper limit on the collection efficiency of the ESP. Anti-sneakage baffles are used to force the sneakage flow to mix with the main gas stream for collection in later sections (EPA, 1998).

Another factor in the performance of ESPs is the resistivity of the collected material. All the ion current must pass through the collected layer to reach the ground plates. This creates an electric field in the layer, and it can become large enough to cause electrical breakdown. When this occurs, new ions of the wrong polarity are injected into the wire-plate gap reducing the charge on the particles, which may cause sparking. This condition is called "back corona." When this happens the collection ability of the unit is reduced. At low resistivities the particles are held on the plates so loosely that reentrainment levels are much higher. Hence, care must be taken in measuring or estimating resistivity because it is strongly affected by such variables as temperature, moisture, gas composition, particle composition, and surface characteristics (EPA, 1999).

Dusts with high resistivities are also not well-suited for collection in dry ESPs. These particles are not easily charged nor easily collected. High-resistivity particles form ash layers with very high voltage gradients on the collecting electrodes lead to back corona, reducing the charge on particles and lowering collection efficiency. Fly ash from the combustion of low-sulfur coal typically has a high resistivity, and thus is difficult to collect using dry ESPs (EPA, 1999).

References:

EPA, 1996: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, EPA 453/B-96-001, Research Triangle Park, NC. February 1996.

EPA, 1998: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

EPA, 1999: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Dry Electrostatic Precipitator (ESP) - Wire-Plate Type," May 1999.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Non-Ferrous Metals Processing - Zinc

Control Measure Name: Wet ESP - Wire Plate Type

Rule Name: Not Applicable

Pechan Measure Code: P2103

POD: 210

Application: This control is the use of a wire-plate type electrostatic precipitator (ESP) to reduce PM emissions. An ESP uses electrical forces to move particles in an exhaust stream onto collector plates. Electrodes in the center of the flow are maintained at high voltage and generate an electrical field forcing particles to the collector walls. Wet ESPs use a stream of water, in place of rapping mechanisms, to dislodge particulate from the plates and into a sump.

This control applies to zinc processing and production operations.

Affected SCC:

30303002 Zinc Production, Multiple Hearth Roaster
30303003 Zinc Production, Sinter Strand
30303005 Zinc Production, Vertical Retort/Electrothermal Furnace
30303006 Zinc Production, Electrolytic Processor
30303009 Zinc Production, Raw Material Handling and Transfer
30400801 Zinc, Retort Furnace
30400802 Zinc, Horizontal Muffle Furnace
30400803 Zinc, Pot Furnace
30400805 Zinc, Galvanizing Kettle
30400812 Zinc, Crushing/Screening of Zinc Residues
30400855 Zinc, Muffle Distillation/Oxidation
30400899 Zinc, Other Not Classified

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: PM10 control efficiency is 99% from uncontrolled; PM2.5 control efficiency is 95% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The following are cost ranges for wire-plate ESPs, developed using EPA cost-estimating spreadsheets for dry wire-plate ESPs with adjustments made to reflect wet wire-plate ESPs (EPA, 1999). Capital and operating costs are generally higher due to noncorrosive materials requirements, increased water usage, and treatment and disposal of wet effluent. When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan,2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed

AT-A-GLANCE TABLE FOR POINT SOURCES

capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 1990). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$30 to \$60 per scfm
Typical value is \$40 per scfm

O&M Costs:

Range from \$6 to \$45 per scfm
Typical value is \$19 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for ESP (EPA, 1999). O&M costs were calculated for three model plants with flow rates of 10, 15 and 20 thousand acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust loading of 6.0 grains per cubic feet. The operating time was assumed to be 8640 hours per year. A water flow rate for the ESP was assumed to be 5 gal/min per thousand acfm. The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.067	\$/kW-hr
Process water price	0.20	\$/1000 gal
Dust disposal	20	\$/ton disposed
Wastewater treatment	1.5	\$/ thousand gal treated

Note: All costs are in 1995 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$55 to \$550 per ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$220 per ton PM10 reduced. (1995\$)

Comments:

Status: Demonstrated

Last Reviewed: 2001

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

Costs can be substantially higher than in the ranges shown for pollutants which require an unusually high level of control, or which require the ESP to be constructed of special materials such as titanium (EPA, 1999). In most cases, smaller units controlling a low concentration waste stream will not be as cost effective as a large unit cleaning a high pollutant load flow (EPA, 1998).

In the wire-plate ESP, the gas flows around vertical, metal plates. The electrodes are long, weighted wires hanging between the plates. The voltage applied to the electrodes causes the gas between the electrodes to break down, known as a "corona." The electrodes are most often given a negative polarity because a negative corona supports a higher voltage than a positive corona.

Certain types of losses affect control efficiency. The dislodging of the accumulated layer also projects some of the particles back into the gas stream. These particles are processed in later sections of the ESP, but the particles from the last section have no chance to be recaptured. Due to the space needed at the top of the ESP for nonelectrified components, part of the stream may flow around the charged zones. This is called "sneakage" and places an upper limit on the collection efficiency of the ESP. Anti-sneakage baffles are used to force the sneakage flow to mix with the main gas stream for collection in later sections (EPA, 1998).

Wire-Plate Type Wet ESPs require a source of wash water near the top of the collector plates. This wash system replaces the rapping mechanism used by dry ESPs. The water flows with the collected particles into a sump from which the fluid is pumped or drained. A portion of the fluid may be recycled to reduce the total amount of water required. The remainder is pumped into a settling pond or passed through a dewatering stage, with subsequent disposal of the sludge (AWMA, 1992).

Unlike dry ESPs, resistivity of the collected material is not a major factor in performance. Because of the high humidity in a wet ESP, the resistivity of particles is lowered, eliminating the "back corona" condition. The frequent washing of the plates also limits particle buildup on the collectors (EPA, 1998).

For wet ESPs, the handling wastewaters must be considered (EPA, 1999). For simple systems with innocuous dusts, water with particles collected by the ESP may be discharged from the ESP system to a solids-removing clarifier. More complicated systems may require skimming and sludge removal, clarification in dedicated equipment, pH adjustment, and/or treatment to remove dissolved solids. Recirculation of treated water to the ESP may approach 100 percent (AWMA, 1992).

References:

AWMA, 1992: Air & Waste Management Association, Air Pollution Engineering Manual, Van Nostrand Reinhold, New York.

EPA, 1996: U.S. EPA, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, EPA 453/B-96-001, Research Triangle Park, NC. February.

EPA, 1998: U.S. EPA, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October.

EPA, 1999: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Wet Electrostatic Precipitator (ESP) - Wire-Plate Type," May 1999

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency,

AT-A-GLANCE TABLE FOR POINT SOURCES

Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Non-Ferrous Metals Processing - Zinc

Control Measure Name: Fabric Filter (Reverse-Air Cleaned Type)

Rule Name: Not Applicable

Pechan Measure Code: P2104

POD: 210

Application: This control is the use of a reverse-air cleaned fabric filter to reduce PM emissions from waste streams. In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Reverse-air cleaning is performed by forcing clean air through the filters in the opposite direction of the dusty gas flow. The change in direction of the gas flow causes the bag to flex and crack the filter cake allowing for internal cake collection.

This control applies to zinc processing and production operations.

Affected SCC:

30303002 Zinc Production, Multiple Hearth Roaster
30303003 Zinc Production, Sinter Strand
30303005 Zinc Production, Vertical Retort/Electrothermal Furnace
30303006 Zinc Production, Electrolytic Processor
30303009 Zinc Production, Raw Material Handling and Transfer
30400801 Zinc, Retort Furnace
30400802 Zinc, Horizontal Muffle Furnace
30400803 Zinc, Pot Furnace
30400805 Zinc, Galvanizing Kettle
30400812 Zinc, Crushing/Screening of Zinc Residues
30400855 Zinc, Muffle Distillation/Oxidation
30400899 Zinc, Other Not Classified

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 99% from uncontrolled for both PM10 and PM2.5

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs for reverse-air cleaned systems are generated using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan,2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 2000). Total installed capital costs were annualized using a capital recovery factor, with is based

AT-A-GLANCE TABLE FOR POINT SOURCES

on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$9 to \$84 per scfm
Typical value is \$34 per scfm

O&M Costs:

Range from \$6 to \$27 per scfm
Typical value is \$13 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). O&M costs were calculated for three model plants with flow rates of 25, 75 and 150 thousand acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust loading of 4.0 grains per cubic feet. The operating time was assumed to be 8760 hours per year. An average bag cost was estimated using the costs for standard bag types. Capital recovery for the periodic replacement of bags was included in the O&M cost of the bags using a bag life of 2 years (EPA, 1998a). The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.0671	\$/kW-hr
Compressed air	0.25	\$/1000 scf
Dust disposal	25	\$/ton disposed

Note: All costs are in 1998 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$53 to \$337 per ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$148 per ton PM10 reduced. (1998\$)

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

The cost estimates assume a conventional design under typical operating conditions. The costs do not include any auxiliary equipment (EPA, 2000).

The capital cost for the reverse-jet cleaned fabric baghouse is based on information provided by a

AT-A-GLANCE TABLE FOR POINT SOURCES

manufacturer (EPA, 2000). The capital cost includes only the purchased equipment cost.

Costs are primarily based on volumetric flow rate and the amount of PM in the waste stream. In general, a small unit controlling a low pollutant levels will not be as cost effective as a large unit controlling a high pollutant levels. (EPA, 2000)

Pollutants requiring a high level of control or the fabric filters to be constructed of special materials will increase the costs of the system (EPA, 1998a). The additional costs for controlling complex streams are not reflected in the estimates. For these systems, the capital cost could increase by as much as 40% and the O&M cost could increase by as much as 5%. (EPA, 2000)

In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Fabric filters may be in the form of sheets, cartridges, or bags, with many individual filter units together in a group. Bags are the most common type of filter. The dust cake that forms on the filter from the collected PM can significantly increase collection efficiency. (EPA, 2000)

Reverse-air cleaning is a popular filter cleaning method as it has been used extensively and improved over the years. It is a gentler but sometimes less effective clearing mechanism than mechanical shaking. Reverse-air cleaning is performed by forcing clean air through the filters in the opposite direction of the dusty gas flow. The change in direction of the gas flow causes the bag to flex and crack the filter cake allowing for internal cake collection (EPA, 2000).

The most common design is to have separate compartments within the fabric filter so that each can be isolated and cleaned separately while the others continue to treat the dusty gas. There are several methods of reversing the flow through the filters. One method of providing the reverse flow is by the use of a fan or cleaned gas from other compartments. Reverse-air cleaning only used alone in cases where the dust releases easily from the fabric. In many instances, reverse-air is used along with shaking, pulsing or sonic horns (EPA, 1998b).

Fabric filters are useful for collecting particles with resistivities either too low or too high for collection with electrostatic precipitators. Fabric filters are useful in controlling particulate matter less than or equal to 10 micrometers (μm) in diameter (PM₁₀) and particulate matter less than or equal to 2.5 μm in diameter (PM_{2.5}). Fabric filters may be good candidates for collecting fly ash from low-sulfur coals or containing high unburned carbon levels and are relatively difficult to collect with electrostatic precipitators. (EPA, 2000)

References:

EPA, 1998b: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

EPA, 1998a: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, Chapter 5, EPA 453/B-96-001, Research Triangle Park, NC. December 1998.

EPA, 2000: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Fabric Filter - Reverse-Air Cleaned Type," April 2000.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Non-Ferrous Metals Processing - Zinc

Control Measure Name: Increased Monitoring Frequency (IMF) of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P3210

POD: 210

Application: This measure is to conduct improved monitoring for PM_{2.5} emissions at stationary sources. Improved monitoring in this case means increasing the monitoring frequency of electrostatic precipitators, scrubbers, and fabric filters from once per day to four times per hour, with no change in monitoring technique.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (Barr and Schaffner) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

304008** Zinc

303030** Zinc Production

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 6.5% for both PM₁₀ and PM_{2.5}

Equipment Life: Not applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs included the incremental record keeping and reporting associated with the increased monitoring frequency. Labor rates for 2003 were made that were obtained from the Bureau of Labor Statistics (labor rates include 140 percent overhead). The incremental costs included a one-time cost for development of the improved monitoring and recurring annual burden costs for incremental record keeping, reporting, and certification activities.

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$620 per ton PM reduced (2003\$).

Comments:

Status:

Last Reviewed: 2004

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM2.5 Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 2003.

BLS, 2003: Bureau of Labor Statistics, "Employer Costs for Employee Compensation – June 2003," Table 12, page 16, 2003.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Non-Ferrous Metals Processing - Zinc

Control Measure Name: CEM Upgrade and Increased Monitoring Frequency of PM Controls

Rule Name: Not Applicable

Pechan Measure Code: P4210

POD: 210

Application: This measure examines the impacts of improving the PM monitoring technique at units currently using an ESP, scrubber, or fabric filter. In this improved technique scenario, the monitoring technique is upgraded to a PM continuous emission monitor. This improved monitoring technique also results in an increase to the monitoring frequency because a PM CEMS can make a measurement every 7.5 minutes. The monitoring frequency increases from once per day to eight times per hour.

RTI's improved monitoring frequency analysis evaluates each scenario for four different excess emission rates (i.e., the sources limit their excess emissions to x percent after the improved monitoring method is applied). The most cost-effective scenarios are those where the source is able to limit excess emissions to less than one percent. The cost effectiveness of this measure is based on a case where the excess emissions are limited to 0.46 percent.

The RTI memo (see References) offers two methods for estimating emission reductions from an NEI baseline. These are labeled the original calculation method, and an alternative calculation method. The original calculation method keeps actual emissions at NEI amounts, and is used in AirControlNET to avoid having to re-estimate NEI emissions to include excess emissions.

Affected SCC:

304008** Zinc

303030** Zinc Production

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 7.7% for both PM10 and PM2.5

Equipment Life: Unknown

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The total capital and annual operating costs for implementing an improved monitoring technique are calculated based on data from the EPA CEMS Cost Model and the PM CEMS Knowledge document. Labor rates in the EPA CEMS Cost Model are scaled to reflect 2003 labor rates (including 140 percent overhead) provided by the Bureau of Labor Statistics.

The cost effectiveness at a percent excess emission rate of 0.46 percent is \$5,200 per ton of PM2.5. This is based on a \$34 million capital investment cost, and a \$14 million total annualized cost when applied to 128 facilities.

Note: All costs are in 2003 dollars.

AT-A-GLANCE TABLE FOR POINT SOURCES

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$5,200 per ton PM reduced (2003\$).

Comments:

Status:

Last Reviewed: 2004

Additional Information:

References:

Barr and Schaffner, 2003: Barr, Leigh and Karen Schaffner, "Impact of Improved Monitoring on PM_{2.5} Emissions," RTI International, memorandum to Barrett Parker, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 8, 2003.

EPA CEMS Cost Model, Version 3.0, U.S. Environmental Protection Agency.

EPA, 2000: U.S. Environmental Protection Agency, "Current Knowledge of Particulate Matter (PM) Continuous Emissions Monitoring," Chapter 9, PM CEMS Cost, September 8, 2000.

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Nonroad Diesel Engines

Control Measure Name: Heavy Duty Retrofit Program

Rule Name: Heavy Duty Retrofit Program

Pechan Measure Code: PHDRET

POD: N/A

Application: The heavy-duty diesel standards regulate emissions from nonroad engines at or above 37 kW (50 horsepower), and emissions from new engines at or above 130 kW (175 horsepower).

This control applies to all non-road diesel engines.

Affected SCC:

2270001060 Recreational Equipment, Specialty Vehicles/Carts
2270002003 Construction and Mining Equipment, Pavers
2270002015 Construction and Mining Equipment, Rollers
2270002018 Construction and Mining Equipment, Scrapers
2270002021 Construction and Mining Equipment, Paving Equipment
2270002024 Construction and Mining Equipment, Surfacing Equipment
2270002027 Construction and Mining Equipment, Signal Boards/Light Plants
2270002030 Construction and Mining Equipment, Trenchers
2270002033 Construction and Mining Equipment, Bore/Drill Rigs
2270002036 Construction and Mining Equipment, Excavators
2270002045 Construction and Mining Equipment, Cranes
2270002048 Construction and Mining Equipment, Graders
2270002051 Construction and Mining Equipment, Off-highway Trucks
2270002054 Construction and Mining Equipment, Crushing/Processing Equipment
2270002057 Construction and Mining Equipment, Rough Terrain Forklifts
2270002060 Construction and Mining Equipment, Rubber Tire Loaders
2270002066 Construction and Mining Equipment, Tractors/Loaders/Backhoes
2270002069 Construction and Mining Equipment, Crawler Tractor/Dozers
2270002072 Construction and Mining Equipment, Skid Steer Loaders
2270002075 Construction and Mining Equipment, Off-highway Tractors
2270002081 Construction and Mining Equipment, Other Construction Equipment
2270003010 Industrial Equipment, Aerial Lifts
2270003020 Industrial Equipment, Forklifts
2270003030 Industrial Equipment, Sweepers/Scrubbers
2270003040 Industrial Equipment, Other General Industrial Equipment
2270003060 Industrial Equipment, AC\Refrigeration
2270003070 Industrial Equipment, Terminal Tractors
2270004056 Lawn and Garden Equipment, Lawn and Garden Tractors (Commercial)
2270004066 Lawn and Garden Equipment, Chippers/Stump Grinders (Commercial)
2270004071 Lawn and Garden Equipment, Turf Equipment (Commercial)
2270005015 Agricultural Equipment, Agricultural Tractors
2270005020 Agricultural Equipment, Combines
2270006005 Commercial Equipment, Generator Sets
2270006010 Commercial Equipment, Pumps
2270006015 Commercial Equipment, Air Compressors
2270006025 Commercial Equipment, Welders
2270007015 Logging Equipment, Forest Eqp - Feller/Bunch/Skidder
2270008005 Airport Ground Support Equipment, Airport Ground Support Equipment

AT-A-GLANCE TABLE FOR AREA SOURCES

2270009010 Underground Mining Equipment, Other Underground Mining Equipment
2270010010 Industrial Equipment, Other Oil Field Equipment

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: PM10 control efficiency is 1% from uncontrolled

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Since source specific data is not available for area and nonroad sources, costs for control measures are simply expressed as the cost per ton reduced (Pechan, 1995). The annual cost is estimated using the following equation:

Annual Cost = Cost Per Ton * Emissions * (Control Efficiency * Rule Effectiveness * Rule Penetration)

Cost-effectiveness, in \$/ton of PM removed, is calculated as the total annual cost divided by the annual PM reduction, in tons.

Cost Effectiveness: The cost effectiveness is \$9,500 per ton PM reduced (1990\$).

Comments: Note: This control measure is currently under evaluation and will be updated in the near future.

Status: Demonstrated

Last Reviewed: 1997

Additional Information:

References:

Pechan, 1995: E.H. Pechan & Associates, Inc., "Regional Particulate Strategies - Draft Report," prepared for U.S. Environmental Agency, Office of Planning and Evaluation, Washington, DC, September 1995.

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Paved Roads

Control Measure Name: Vacuum Sweeping

Rule Name: Not Applicable

Pechan Measure Code: PPVAC

POD: N/A

Application: Vacuum sweeping is a road surface cleaning operation that removes loose material from the roadway, preventing it from becoming airborne particulate when vehicles travel over the road surface.

This control applies to all paved roads classified under SCC 2294000000.

Affected SCC:

2294000000 All Paved Roads, Total: Fugitives

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: PM10 control efficiency is 51% from uncontrolled; PM2.5 control efficiency is 25% from uncontrolled

Equipment Life: 8 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Capital costs vary from \$150K to \$190K (1999 dollars) for compressed natural gas (CNG) fueled units. Diesel-powered units are approximately \$30K less (Harrison, 1999).

Unit life is approximately 5 years; however, with thorough maintenance, life can be extended to 8 years. For best performance, operating speed is limited to 5 miles per hour. Based on a 7 percent discount rate and 8-year life, annualized costs are \$25K to \$32K.

O&M costs are approximately \$16 to \$18 per curb mile, based on operation with CNG, a thorough maintenance regimen, and a wage scale of approximately \$13/hr (Clapper, 1999).

Note: All costs are in 1999 dollars.

Cost Effectiveness: The cost effectiveness for this control is \$485 per ton PM reduced. (1999\$)

Comments:

Status: Demonstrated

Last Reviewed: 1999

Additional Information:

The closed-loop regenerative air vacuum systems use an air jet generated by a blower and distributed by the floating pickup head to loosen particles in the surface cracks and crevices before drawing them into an internal hopper. A mechanical broom precedes the vacuum section (Pechan,

AT-A-GLANCE TABLE FOR AREA SOURCES

1999). No water is used. An internal centrifugal dust separator retains and collects the PM for proper disposal.

References:

Clapper, 1999: W. Clapper, Sunline Transit Services, personal communication with J. Reisman, E.H. Pechan & Associates, Inc., August 18, 1999.

Harrison, 1999: J. Harrison, GCS Western Power, personal communication with J. Reisman, E.H. Pechan & Associates, Inc., August 18, 1999.

Pechan, 1999: E.H. Pechan & Associates, Inc., "Control Measure Evaluations: The Control Measure Data Base for the National Emissions Trends Inventory (Control NET)," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 1999

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Prescribed Burning

Control Measure Name: Increase Fuel Moisture

Rule Name: Not Applicable

Pechan Measure Code: Ppreb

POD: N/A

Application: Prescribed burning is defined as the intentional burning of forest and range lands. For forestry burning, increasing the fuel moisture will decrease particulate emissions by decreasing the amount of fuel burned.

This control is applicable to prescribed burning for forest management.

Affected SCC:

2810015000 Prescribed Burning for Forest Management, Total

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 50% from uncontrolled for both PM10 and PM2.5

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: EPA estimated a range of \$38 to \$161 per acre cost for increasing fuel moisture in 1986 (EPA, 1992). Costs vary based on the current burn schedule and method, along with the type of land under consideration (federal versus private).

Based on the emission factor for PM10 emissions and the 50 percent control efficiency, a \$826-\$3,500 PM10 cost per ton range (in 1986 dollars) is estimated.

For PM10: $((\$38-\$161 \text{ per acre}) / (0.092 \text{ tons PM-10/acre})) * ((1 \text{ ton emitted}) / (0.50 \text{ ton reduced})) = \$826-\$3,500 \text{ per ton PM10 reduced (in 1986 dollars)}$

Because this measure entails work practice changes, costs were converted to 1990 dollar terms using the 1986-1990 producer price index for employment costs (BLS, 1994).

For PM10: $\$826-\$3,500 \text{ per ton in 1986 dollars} * 1.21 = \$999-\$4,235 \text{ per ton PM10 reduced (in 1990 dollars)}$

The midpoint of these cost ranges was used in the analysis, PM10 costs are estimated at \$2,617 per ton.

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$2,617 per ton PM reduced (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 1997

AT-A-GLANCE TABLE FOR AREA SOURCES

Additional Information:

Decreasing PM emissions is accomplished by either removing lighter and drier fuels or burning in early spring when moisture levels are naturally higher. Emission reductions estimates range from 30 to more than 50 percent (EPA, 1992; Hardy, 1997). Reductions will vary significantly depending on a given area. Variation is based on current burn schedule and method, along with the characteristics of the material to be burned.

References:

BLS, 1994: U.S. Department of Labor, Bureau of Labor Statistics, Producer Price Indices, Washington DC. Various issues 1985 through 1994.

EPA, 1992: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Prescribed Burning Background Document and Technical Information Document for Best Available Control Measures, Research Triangle Park, NC. September 1992.

Hardy, 1997: C. Hardy, Intermountain Research Station, USDA Forest Service, Forest Service Fire Research Library, Missoula, MT, personal communication with M. Cohen, E.H. Pechan & Associates, Inc. February 1997.

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Residential Wood Combustion

Control Measure Name: Education and Advisory Program

Rule Name: Education and Advisory Program

Pechan Measure Code: Presw

POD: N/A

Application: The education and advisory programs provide instruction in proper wood burning operation and maintenance of a wood stove as well as the hazards of wood stove emissions.

Residential wood combustion (RWC) emissions include those from traditional masonry fireplaces, freestanding fireplaces (metal zero clearance), wood stoves, and furnaces.

Affected SCC:

2104008001 Wood, Fireplaces

2104008030 Wood, Catalytic Woodstoves: General

2104008051 Wood, Non-catalytic Woodstoves: Conventional

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 50% from uncontrolled for both PM10 and PM2.5

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Costs of education and advisory programs are variable since they are dependent on program parameters and area characteristics. The costs here are based on the Clement Falls, Oregon education and advisory program and mandatory curtailment program. It is assumed that the costs are proportional to population. This results in a per capita cost of \$0.79 for the education and advisory program, \$0.01 for the forecasting system, and \$0.02 for the mandatory curtailment program.

The cost per ton reduced varies depending on the assumed fraction of Phase II woodstoves versus conventional woodstoves. Here the percentage of Phase II stoves is assumed to be 72% (Pechan, 1997).

Cost Effectiveness: The cost effectiveness is \$1,320 per ton PM10 reduced (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 1997

Additional Information:

In many areas of the country with PM10 nonattainment designations, residential wood combustion devices account for a large fraction of PM emissions in the winter.

References:

Pechan, 1997: E.H. Pechan & Associates, "Additional Control Measure Evaluation for the Integrated Implementation of the Ozone and Particulate Matter National Ambient Air Quality Standards, and Regional Haze Program," prepared for U.S. Environmental Protection Agency, July 1997.

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Residential Wood Stoves

Control Measure Name: NSPS compliant Wood Stoves

Rule Name: Not Applicable

Pechan Measure Code: Pwdstv

POD: N/A

Application: The key to EPA-certified woodburning appliances is more complete combustion. Uncertified stoves starve the fire of oxygen which burns wood incompletely, and creates excessive levels of smoke. In contrast, certified appliances create the right conditions for complete combustion – high temperature, enough oxygen, or air, and sufficient time for the combustion gases to burn before being cooled.

Affected SCC:

2104008010 Stationary Source Fuel Combustion, Residential, Wood, WoodStoves: General

2104008050 Stationary Source Fuel Combustion, Residential, Wood, WoodStoves: General, Non-Catalytic WoodStoves - General

2104008051 Stationary Source Fuel Combustion, Residential, Wood, WoodStoves: General, Non-Catalytic WoodStoves - Conventional

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√*								

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 98% from uncontrolled

Equipment Life: Not Applicable

Rule Effectiveness: 90%

Penetration: 100%

Cost Basis: The Cost effectiveness is \$2,000/ton of PM reduced (2001\$).

Cost Effectiveness: The Cost effectiveness is \$2,000/ton of PM reduced (2001\$).

Comments:

Status: Demonstrated

Last Reviewed: 2005

Additional Information:

References:

Personal Email Communication with Larry Sorrels, EPA dated September 16, 2005

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Unpaved Roads

Control Measure Name: Chemical Stabilization

Rule Name: Not Applicable

Pechan Measure Code: PUCHS

POD: N/A

Application: Chemical stabilization is a surface treatment option for unpaved roads. Unpaved roads comprise a sizable percentage of total PM10/PM2.5 emissions. Unpaved roads, especially rural roads, do not generally experience the type of traffic volume associated with paved roads.

This control applies to unpaved roads classified under SCC 2296000000.

Affected SCC:

2296000000 All Unpaved Roads, Total: Fugitives

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√							

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: PM10 control efficiency is 38% from uncontrolled; PM2.5 control efficiency is 25% from uncontrolled

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: SCAQMD estimated a \$17,000 per mile cost estimate for chemical stabilization of unpaved roads for the 1994 Air Quality Management Plan (SCAQMD, 1994). From this, Pechan estimated a cost effectiveness of \$2,753 per ton PM removed.

Cost Effectiveness: The cost effectiveness is \$2,753 per ton PM removed (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 1997

Additional Information:

Chemical stabilization was investigated as a supplemental control option to hot asphalt paving for urban areas. For rural areas, chemical stabilization was evaluated as an alternative to watering (Pechan, 1995).

The control application parameters that affect the control efficiency of chemical dust suppressants are application intensity, application frequency, dilution ratio and application procedure (EPA, 1986). Other factors that influence the control efficiency are the silt content of the soil, weather conditions and the weight and level of traffic. An increase in vehicle weight and speed serves to accelerate the decay in efficiency for chemical suppression.

AT-A-GLANCE TABLE FOR AREA SOURCES

References:

EPA, 1986: U.S. Environmental Protection Agency, Air and Engineering Research Laboratory, Identification, Assessment, and Control of Fugitive Particulate Emissions, EPA/600/8-86/023, prepared by Midwest Research Institute, August 1986.

Pechan, 1995: E.H. Pechan & Associates, Inc., "Regional Particulate Strategies, Draft Report," prepared for U.S. Environmental Protection Agency, Office of Policy Planning and Evaluation, Washington, DC. September 1995.

SCAQMD, 1994: South Coast Air Quality Management District, "1994 Air Quality Management Plan, Appendix I-D: Best Available Control Measures PM-10 SIP for the South Coast Air Basin," April 1994.

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Unpaved Roads

Control Measure Name: Hot Asphalt Paving

Rule Name: Not Applicable

Pechan Measure Code: PUHAP

POD: N/A

Application: This control is the paving of unpaved roads with hot asphalt. Hot asphalt paving is based on the use of paving materials which meet RACT requirements and thereby do not emit VOCs. Hot asphalt paving was selected as the control option for urban areas.

This control measure applies to all unpaved roads classified under SCC 2296000000.

Affected SCC:

2296000000 All Unpaved Roads, Total: Fugitives

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: PM10 control efficiency is 68% from uncontrolled; PM2.5 control efficiency is 25% from uncontrolled

Equipment Life: 40 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: In determining per VMT cost, average daily traffic (ADT) is assumed to be 400 for urban roads (Pechan, 1995). The cost of hot asphalt paving is \$0.08 per VMT (Pechan, 1995). Once the control options have been weighted the annual cost for urban areas is \$0.09 per VMT.

The capital cost is determined in a similar manner to the annual costs, resulting in a total capital cost of \$0.43 per VMT.

Cost Effectiveness: The cost effectiveness per ton PM10 reduced is \$537 (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 1999

Additional Information:

This control technique is not applied in rural areas because of the high cost relative to the emission reduction potential.

References:

Pechan, 1995: E.H. Pechan & Associates, Inc., "Regional Particulate Strategies - Draft Report," prepared for U.S. Environmental Agency, Office of Planning and Evaluation, Washington, DC, September 1995.

AT-A-GLANCE TABLE FOR UTILITY SOURCES

Source Category: Utility Boilers - Coal

Control Measure Name: Dry ESP-Wire Plate Type

Rule Name: Not Applicable

Pechan Measure Code: PUDESP

POD: 01

Application: This control is the use of an electrostatic precipitator (ESP) to reduce PM emissions. An ESP uses electrical forces to move particles in an exhaust stream onto collector plates. Electrodes in the center of the flow are maintained at high voltage and generate an electrical field forcing particles to the collector walls. In dry ESPs, the collectors are knocked by various mechanical means to dislodge the particulate, which slides downward into a hopper.

This control applies to electricity generation sources powered by pulverized dry-bottom and bituminous/subbituminous coal.

Affected SCC:

10100202 Electric Generation, Pulverized-Dry Bottom (Bituminous Coal)

10100203 Electric Generation, Bituminous/Subbituminous Coal, Cyclone Furnace (Bituminous)

10100212 Electric Generation, Pulverized Coal-Dry Bottom (Tangential) (Bituminous Coal)

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						√

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: PM10 control efficiency is 98% from uncontrolled; PM2.5 control efficiency is 95% from uncontrolled; Hg control efficiency is 20% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs for ESPs of conventional design under typical operating conditions are developed using EPA cost estimating spreadsheets (EPA, 1996). When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan, 2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 1999). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual,

AT-A-GLANCE TABLE FOR UTILITY SOURCES

with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$15 to \$50 per scfm
Typical value is \$27 per scfm

O&M Costs:

Range from \$4 to \$40 per scfm
Typical value is \$16 per scfm

Note: All costs are in 1995 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$40 to \$250 per ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$110 per ton PM10 reduced. (1995\$)

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

In the wire-plate ESP, the gas flows around vertical, metal plates. The electrodes are long, weighted wires hanging between the plates. The voltage applied to the electrodes causes the gas between the electrodes to break down, known as a "corona." The electrodes are most often given a negative polarity because a negative corona supports a higher voltage than a positive corona.

Certain types of losses affect control efficiency. The dislodging of the accumulated layer also projects some of the particles back into the gas stream. These particles are processed in later sections of the ESP, but the particles from the last section have no chance to be recaptured. Due to the space needed at the top of the ESP for nonelectrified components, part of the stream may flow around the charged zones. This is called "sneakage" and places an upper limit on the collection efficiency of the ESP. Anti-sneakage baffles are used to force the sneakage flow to mix with the main gas stream for collection in later sections (EPA, 1998).

Another factor in the performance of ESPs is the resistivity of the collected material. All the ion current must pass through the collected layer to reach the ground plates. This creates an electric field in the layer, and it can become large enough to cause electrical breakdown. When this occurs, new ions of the wrong polarity are injected into the wire-plate gap reducing the charge on the particles, which may cause sparking. This condition is called "back corona." When this happens the collection ability of the unit is reduced. At low resistivities the particles are held on the plates so loosely that reentrainment levels are much higher. Hence, care must be taken in measuring or estimating resistivity because it is strongly affected by such variables as temperature, moisture, gas composition, particle composition, and surface characteristics (EPA, 1999).

Dusts with high resistivities are also not well-suited for collection in dry ESPs. These particles are not easily charged nor easily collected. High-resistivity particles form ash layers with very high voltage gradients on the collecting electrodes lead to back corona, reducing the charge on particles

AT-A-GLANCE TABLE FOR UTILITY SOURCES

and lowering collection efficiency. Fly ash from the combustion of low-sulfur coal typically has a high resistivity, and thus is difficult to collect using dry ESPs (EPA, 1999).

The particulate-bound form of mercury can be readily captured in the particulate matter (PM) control devices, e.g., fabric filters (FF). Also, gaseous mercury (both Hg⁰ and Hg²⁺) can potentially be adsorbed on fly ash and subsequently be collected on a PM device. However, the level of this adsorption depends on the speciation of mercury, the flue gas concentration of fly ash, and many other factors.

Average mercury capture efficiencies of PM post-combustion control measures for coal-fired utility boilers are based on research data from National Risk Management Research Laboratory (EPA, 2002). Control efficiencies are based on a series of tests conducted on a several plants throughout the United States. The background documents to National Risk Management Research Laboratory Study (EPA, 2002) also provided estimates of control efficiencies of Hg species for a limited number of tests

References:

EPA, 1996: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, EPA 453/B-96-001, Research Triangle Park, NC. February 1996.

EPA, 1998: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

EPA, 1999: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Dry Electrostatic Precipitator (ESP) - Wire-Plate Type," May 1999.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Research and Development, Control Of Mercury Emissions From Coal-Fired Electric Utility Boilers: Interim Report Including Errata Dated 3-21-02," EPA-600/R-01-109, April 2002.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

AT-A-GLANCE TABLE FOR UTILITY SOURCES

Source Category: Utility Boilers - Coal

Control Measure Name: Fabric Filter (Mech. Shaker Type)

Rule Name: Not Applicable

Pechan Measure Code: PUMECH

POD: 01

Application: This control is the addition of a mechanical shaker type fabric filter to reduce PM emissions from utility boiler waste streams. In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. The gas stream is drawn from beneath a cell plate in the floor and into the filter bags. The gas proceeds from the inside to the outside of the filter bags. The particles collect on the inside of the bags, forming a filter cake. In mechanical shaking units, the tops of bags are attached to a shaker bar, moved briskly to clean the bags.

This control applies to electricity generation sources powered by pulverized dry-bottom and bituminous/subbituminous coal.

Affected SCC:

10100202 Electric Generation, Pulverized-Dry Bottom (Bituminous Coal)

10100203 Electric Generation, Bituminous/Subbituminous Coal, Cyclone Furnace (Bituminous)

10100212 Electric Generation, Pulverized Coal-Dry Bottom (Tangential) (Bituminous Coal)

10100217 Bituminous/Subbituminous Coal, Atm. Fluidized Bed Combustion-Bubbling (Bituminous)

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						√

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 99% from uncontrolled for both PM10 and PM2.5

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs for mechanical shaker cleaned systems are generated using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan,2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 2000). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of

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equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$8 to \$71 per scfm
Typical value is \$29 per scfm

O&M Costs:

Range from \$4 to \$24 per scfm
Typical value is \$11 per scfm

Note: All costs are in 1998 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$37 to \$303 per ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$126 per ton PM10 reduced. (1998\$)

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

Cost estimates assume a conventional design under typical operating conditions. The costs do not include auxiliary equipment such as fans and ductwork. (EPA, 2000)

Costs are primarily based on volumetric flow rate and the amount of PM in the waste stream. In general, a small unit controlling a low pollutant levels will not be as cost effective as a large unit controlling a high pollutant levels. (EPA, 2000)

Pollutants requiring a high level of control or the fabric filters to be constructed of special materials will increase the costs of the system (EPA, 1998a). The additional costs for controlling complex waste streams are not included in the estimates. For these systems, the capital cost could increase by as much as 30% and the O&M cost could increase by as much as 7%.

In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Fabric filters may be in the form of sheets, cartridges, or bags, with many individual filter units together in a group. Bags are the most common type of filter. The dust cake that forms on the filter from the collected PM can significantly increase collection efficiency. (EPA, 2000)

Mechanical shaking is a popular cleaning method because it is both simple and effective. In typical operation, dusty gas enters an inlet pipe to the fabric filter and very large particles are removed using a baffle plate fall into the hopper. The gas stream is drawn from beneath a cell plate in the floor and into the filter bags (EPA, 2000). The gas proceeds from the inside to the outside of the filter bags. The particles collect on the inside of the bags, forming a filter cake. In mechanical shaking units, the tops of bags are attached to a shaker bar, moved briskly (usually in a horizontal direction) to clean the bags. The shaker bars are operated by mechanical motors or by hand (EPA,

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1998b)..

Fabric filters are useful for collecting particles with resistivities either too low or too high for collection with electrostatic precipitators. Fabric filters are useful in controlling particulate matter less than or equal to 10 micrometers (μm) in diameter (PM₁₀) and particulate matter less than or equal to 2.5 μm in diameter (PM_{2.5}). Fabric filters may be good candidates for collecting fly ash from low-sulfur coals or containing high unburned carbon levels and are relatively difficult to collect with electrostatic precipitators. (EPA, 2000)

References:

EPA, 1998a: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, Chapter 5, EPA 453/B-96-001, Research Triangle Park, NC. December 1998.

EPA, 1998b: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

EPA, 2000: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Fabric Filter - Mechanical Shaker Cleaned Type," August 2000.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

AT-A-GLANCE TABLE FOR UTILITY SOURCES

Source Category: Utility Boilers - Coal

Control Measure Name: Fabric Filter (Pulse Jet Type)

Rule Name: Not Applicable

Pechan Measure Code: PUPUJT

POD: 01

Application: This control is the addition of a pulse-jet cleaned fabric filter to reduce PM emissions from waste streams from coal-fired utility boilers. In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Particulate-laden gas flows into the filter bag from the outside to the inside. The particles collected on the outside drop into a hopper below the fabric filter. During pulse-jet cleaning, a short burst of high pressure air is injected into the bags, dislodging the dust cake.

This control applies to electricity generation sources powered by pulverized dry-bottom and bituminous/subbituminous coal.

Affected SCC:

10100202 Electric Generation, Pulverized-Dry Bottom (Bituminous Coal)

10100203 Electric Generation, Bituminous/Subbituminous Coal, Cyclone Furnace (Bituminous)

10100212 Electric Generation, Pulverized Coal-Dry Bottom (Tangential) (Bituminous Coal)

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						√

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 99% from uncontrolled for both PM10 and PM2.5

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs for pulse-jet cleaned systems are generated using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan,2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 2000). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual,

AT-A-GLANCE TABLE FOR UTILITY SOURCES

with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$6 to \$26 per scfm
Typical value is \$13 per scfm

O&M Costs:

Range from \$5 to \$24 per scfm
Typical value is \$11 per scfm

Note: All costs are in 1998 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$42 to \$266 per ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$117 per ton PM10 reduced. (1998\$)

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

The cost estimates assume a conventional design under typical operating conditions and do not include auxiliary equipment such as fans and ductwork. The costs for pulse-jet cleaned systems are generated using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a).

Costs are primarily based on volumetric flow rate and the amount of PM in the waste stream. In general, a small unit controlling a low pollutant levels will not be as cost effective as a large unit controlling a high pollutant levels. (EPA, 2000)

Pollutants requiring a high level of control or the fabric filters to be constructed of special materials will increase the costs of the system (EPA, 1998a). The additional costs for controlling complex waste streams are not included in the estimates. For these systems, the capital cost could increase by as much as 75% and the operational and maintenance (O&M) cost could increase by as much as 20% (EPA, 2000).

In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Fabric filters may be in the form of sheets, cartridges, or bags, with many individual filter units together in a group. Bags are the most common type of filter. The dust cake that forms on the filter from the collected PM can significantly increase collection efficiency. (EPA, 2000)

Pulse-jet cleaning of fabric filters is a relatively new type of fabric filter, as they have only been used for the past 30 years. This cleaning mechanism has grown in popularity because it can treat high dust loadings, operate at constant pressure drop, and occupy less space than other types of fabric filters (EPA, 2000). Particulate-laden gas flows into the bag. The gas flows from the outside to the inside of the bags, and then out the gas exhaust. The particles collected on the outside drop into a hopper below the fabric filter (EPA, 1998b).

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During pulse-jet cleaning, a short burst of high pressure air is injected into the bags (EPA, 1998b). The pulse is blown through a venturi nozzle at the top of the bags and establishes a shock wave that continues onto the bottom of the bag. The wave flexes the fabric dislodging the dust cake.

There are several unique attributes of pulse-jet cleaning. The cleaning pulse is very brief allowing the flow of dusty gas to continue during cleaning. The bags not being cleaned continue to filter, taking on extra duty from the bags being cleaned (EPA, 2000). Pulse-jet cleaning is more intense and occurs with greater frequency than the other fabric filter cleaning methods. The cleaning dislodges nearly all of the dust cake each time the bag is pulsed. Pulse-jet filters, as a result, do not rely on a dust cake to provide filtration. Felted (non-woven) fabrics are used in these types of filters because they do not require a dust cake. Also it has been found that woven fabrics used with pulse-jet cleaning leak dust after they are cleaned (EPA, 1998b).

Since bags cleaned by the pulse-jet method do not need to be isolated for cleaning, pulsejet cleaned fabric filters do not need extra compartments to maintain adequate filtration during cleaning. Also, because of the intense and frequent nature of the cleaning, they can treat higher gas flow rates with higher dust loadings. Consequently, fabric filters cleaned by the pulse-jet method can be smaller than other filters in the treatment of the same amount of gas and dust, making higher gas-to-cloth ratios achievable (EPA, 1998b).

Fabric filters are useful for collecting particles with resistivities either too low or too high for collection with electrostatic precipitators. Fabric filters are useful in controlling particulate matter less than or equal to 10 micrometers (μm) in diameter (PM₁₀) and particulate matter less than or equal to 2.5 μm in diameter (PM_{2.5}). Fabric filters may be good candidates for collecting fly ash from low-sulfur coals or containing high unburned carbon levels and are relatively difficult to collect with electrostatic precipitators. (EPA, 2000)

References:

EPA, 1998a: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, Chapter 5, EPA 453/B-96-001, Research Triangle Park, NC. December 1998.

EPA, 1998b: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

EPA, 2000: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Fabric Filter - Pulse-Jet Cleaned Type," April 2000.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

AT-A-GLANCE TABLE FOR UTILITY SOURCES

Source Category: Utility Boilers - Coal

Control Measure Name: Fabric Filter (Reverse-Air Cleaned Type)

Rule Name: Not Applicable

Pechan Measure Code: PUREVA

POD: 01

Application: This control is the use of a reverse-air cleaned fabric filter to reduce PM emissions from waste streams from coal-fired utility boilers. In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Reverse-air cleaning is performed by forcing clean air through the filters in the opposite direction of the dusty gas flow. The change in direction of the gas flow causes the bag to flex and crack the filter cake allowing for internal cake collection.

This control applies to electricity generation sources powered by pulverized dry-bottom and bituminous/subbituminous coal.

Affected SCC:

10100202 Electric Generation, Pulverized-Dry Bottom (Bituminous Coal)

10100203 Electric Generation, Bituminous/Subbituminous Coal, Cyclone Furnace (Bituminous)

10100212 Electric Generation, Pulverized Coal-Dry Bottom (Tangential) (Bituminous Coal)

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						√

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 99% from uncontrolled for both PM10 and PM2.5

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs for reverse-air cleaned systems are generated using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998a). When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan,2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 2000). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of

AT-A-GLANCE TABLE FOR UTILITY SOURCES

equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$9 to \$84 per scfm
Typical value is \$34 per scfm

O&M Costs:

Range from \$6 to \$27 per scfm
Typical value is \$13 per scfm

Note: All costs are in 1998 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$53 to \$337 per ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$148 per ton PM10 reduced. (1998\$)

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

The cost estimates assume a conventional design under typical operating conditions. The costs do not include any auxiliary equipment (EPA, 2000).

The capital cost for the reverse-jet cleaned fabric baghouse is based on information provided by a manufacturer (EPA, 2000). The capital cost includes only the purchased equipment cost.

Costs are primarily based on volumetric flow rate and the amount of PM in the waste stream. In general, a small unit controlling a low pollutant levels will not be as cost effective as a large unit controlling a high pollutant levels. (EPA, 2000)

Pollutants requiring a high level of control or the fabric filters to be constructed of special materials will increase the costs of the system (EPA, 1998a). The additional costs for controlling complex streams are not reflected in the estimates. For these systems, the capital cost could increase by as much as 40% and the O&M cost could increase by as much as 5%. (EPA, 2000)

In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Fabric filters may be in the form of sheets, cartridges, or bags, with many individual filter units together in a group. Bags are the most common type of filter. The dust cake that forms on the filter from the collected PM can significantly increase collection efficiency. (EPA, 2000)

Reverse-air cleaning is a popular filter cleaning method as it has been used extensively and improved over the years. It is a gentler but sometimes less effective clearing mechanism than mechanical shaking. Reverse-air cleaning is performed by forcing clean air through the filters in the opposite direction of the dusty gas flow. The change in direction of the gas flow causes the bag to flex and crack the filter cake allowing for internal cake collection (EPA, 2000).

AT-A-GLANCE TABLE FOR UTILITY SOURCES

The most common design is to have separate compartments within the fabric filter so that each can be isolated and cleaned separately while the others continue to treat the dusty gas. There are several methods of reversing the flow through the filters. One method of providing the reverse flow is by the use of a fan or cleaned gas from other compartments. Reverse-air cleaning only used alone in cases where the dust releases easily from the fabric. In many instances, reverse-air is used along with shaking, pulsing or sonic horns (EPA, 1998b).

Fabric filters are useful for collecting particles with resistivities either too low or too high for collection with electrostatic precipitators. Fabric filters are useful in controlling particulate matter less than or equal to 10 micrometers (μm) in diameter (PM10) and particulate matter less than or equal to 2.5 μm in diameter (PM2.5). Fabric filters may be good candidates for collecting fly ash from low-sulfur coals or containing high unburned carbon levels and are relatively difficult to collect with electrostatic precipitators. (EPA, 2000)

References:

EPA, 1998b: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter, EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

EPA, 1998a: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, Chapter 5, EPA 453/B-96-001, Research Triangle Park, NC. December 1998.

EPA, 2000: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Fabric Filter - Reverse-Air Cleaned Type," April 2000.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

AT-A-GLANCE TABLE FOR UTILITY SOURCES

Source Category: Utility Boilers - Coal

Control Measure Name: Fabric Filter

Rule Name: Not Applicable

Pechan Measure Code: PUTILC

POD: 01

Application: This control is the use of a fabric filter on waste streams to reduce PM emissions. In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms.

This control applies to electricity generation sources powered by pulverized dry-bottom and bituminous/subbituminous coal.

Affected SCC:

10100202 Electric Generation, Pulverized-Dry Bottom (Bituminous Coal)

10100203 Electric Generation, Bituminous/Subbituminous Coal, Cyclone Furnace (Bituminous)

10100212 Electric Generation, Pulverized Coal-Dry Bottom (Tangential) (Bituminous Coal)

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						√

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 95% from uncontrolled for both PM10 and PM2.5; 80% from uncontrolled for Hg

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs.

Capital Costs (TCC):

Stackflow: stkflow (ft³ / min)

Total Equipment Cost Factor: tecs = 5.7019

Total Equipment Cost Constant: teci = 77,489

Equipment to Capital Cost Multiplier: ec_to_cc

$$TCC = [(tecs * stkflow) + teci] * ec_to_cc$$

Operating and Maintenance Costs (O&M) are comprised of electricity, dust disposal and bag replacement (compressed air is not applicable).

Electricity Factor: els = 0.1941

Electricity Constant: eli = -15.956

Dust Disposal Factor: dds = 0.7406

Dust Disposal Constant: ddi = 1.1461

Bag Replacement Factor: brs = 0.2497

Bag Replacement Constant: bri = 1220.7

$$O\&M = [(els * stkflow) + eli] + [(dds * stkflow) + ddi] + [(brs * stkflow) + bri]$$

AT-A-GLANCE TABLE FOR UTILITY SOURCES

Equipment Life in Years = Equiplife

Interest Rate = i = 7 percent

Capital Recovery Factor: $CRF = [i(1+i)^{\text{Equiplife}}] / [(1+i)^{\text{Equiplife}} - 1]$

Total Costs = $(CRF * TCC) + O\&M$

Note: All resulting costs are in 1990 dollars.

Cost Effectiveness: Cost effectiveness will vary depending on stack flow. The cost effectiveness is based on the calculation of total capital costs and operation and maintenance costs. (All resulting costs are in 1990 dollars.)

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Fabric filters may be in the form of sheets, cartridges, or bags, with many individual filter units together in a group. Bags are the most common type of filter. The dust cake that forms on the filter from the collected PM can significantly increase collection efficiency. (EPA, 2000)

Fabric filters are useful for collecting particles with resistivities either too low or too high for collection with electrostatic precipitators. Fabric filters are useful in controlling particulate matter less than or equal to 10 micrometers (μm) in diameter (PM₁₀) and particulate matter less than or equal to 2.5 μm in diameter (PM_{2.5}). Fabric filters may be good candidates for collecting fly ash from low-sulfur coals or containing high unburned carbon levels and are relatively difficult to collect with electrostatic precipitators. (EPA, 2000)

The particulate-bound form of mercury can be readily captured in the particulate matter (PM) control devices, e.g., fabric filters (FF). Also, gaseous mercury (both Hg⁰ and Hg²⁺) can potentially be adsorbed on fly ash and subsequently be collected on a PM device. However, the level of this adsorption depends on the speciation of mercury, the flue gas concentration of fly ash, and many other factors.

Average mercury capture efficiencies of PM post-combustion control measures for coal-fired utility boilers are based on research data from National Risk Management Research Laboratory (EPA, 2002). Control efficiencies are based on a series of tests conducted on a several plants throughout the United States. The background documents to National Risk Management Research Laboratory Study (EPA, 2002) also provided estimates of control efficiencies of Hg species for a limited number of tests

References:

EPA, 2000: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Fabric Filter - Reverse-Air Cleaned Type," April 2000.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Research and Development, Control Of Mercury Emissions From Coal-Fired Electric Utility Boilers: Interim Report Including Errata Dated 3-21-02," EPA-600/R-01-109, April 2002.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter

AT-A-GLANCE TABLE FOR UTILITY SOURCES

Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

AT-A-GLANCE TABLE FOR UTILITY SOURCES

Source Category: Utility Boilers - Gas/Oil

Control Measure Name: Fabric Filter

Rule Name: Not Applicable

Pechan Measure Code: PUTILG

POD: 05

Application: This control is the use of a fabric filter on waste streams to reduce PM emissions. In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms.

This control applies to electricity generation sources powered by natural gas.

Affected SCC:

10100601 Electric Generation, Natural Gas, Boilers > 100 Million Btu/hr except Tangential

10100604 Electric Generation, Natural Gas, Tangentially Fired Units

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						√

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 95% from uncontrolled for both PM10 and PM2.5

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs.

Capital Costs (TCC):

Stackflow: stkflow (ft³ / min)

Total Equipment Cost Factor: tecs = 5.7019

Total Equipment Cost Constant: teci = 77,489

Equipment to Capital Cost Multiplier: ec_to_cc

$$TCC = [(tecs * stkflow) + teci] * ec_to_cc$$

Operating and Maintenance Costs (O&M) are comprised of electricity, dust disposal and bag replacement (compressed air is not applicable).

Electricity Factor: els = 0.1876

Electricity Constant: eli = -19.576

Dust Disposal Factor: dds = 0.0007

Dust Disposal Constant: ddi = 0.1895

Bag Replacement Factor: brs = 0.2411

Bag Replacement Constant: bri = 1224.2

$$O\$M = [(els * stkflow) + eli] + [(dds * stkflow) + ddi] + [(brs * stkflow) + bri]$$

AT-A-GLANCE TABLE FOR UTILITY SOURCES

Equipment Life in Years = Equiplife

Interest Rate = i

Capital Recovery Factor: $CRF = [i(1+i)^{\text{Equiplife}}] / [(1+i)^{\text{Equiplife}} - 1]$

Total Costs = $(CRF * TCC) + O\&M$

Note: All resultant costs are in 1990 dollars.

Cost Effectiveness: Cost effectiveness will vary depending on stack flow. The cost effectiveness is based on the calculation of total capital costs and operation and maintenance costs. (All resulting costs are in 1990 dollars.)

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

In a fabric filter, flue gas is passed through a tightly woven or felted fabric, collecting PM by sieving and other mechanisms. Fabric filters may be in the form of sheets, cartridges, or bags, with many individual filter units together in a group. Bags are the most common type of filter. The dust cake that forms on the filter from the collected PM can significantly increase collection efficiency. (EPA, 2000)

Fabric filters are useful for collecting particles with resistivities either too low or too high for collection with electrostatic precipitators. Fabric filters are useful in controlling particulate matter less than or equal to 10 micrometers (μm) in diameter (PM₁₀) and particulate matter less than or equal to 2.5 μm in diameter (PM_{2.5}). Fabric filters may be good candidates for collecting fly ash from low-sulfur coals or containing high unburned carbon levels and are relatively difficult to collect with electrostatic precipitators. (EPA, 2000)

References:

EPA, 2000: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Fabric Filter - Reverse-Air Cleaned Type," April 2000.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

WDNR, 2000: Wisconsin Department of Natural Resources, "One-hour Ozone Attainment Demonstration, State Implementation Plan and Rate of Progress Rules - Attachment 4, Stationary Source NO_x Control Program," Wisconsin Department of Natural Resources, December 2000.
<http://www.dnr.state.wi.us/org/aw/air/hot/dec00sip/attachment4.pdf>

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Wood Pulp & Paper

Control Measure Name: Dry ESP-Wire Plate Type

Rule Name: Not Applicable

Pechan Measure Code: P2241

POD: 224

Application: This control is the use of dry electrostatic precipitators (ESP) to reduce PM emissions. An ESP uses electrical forces to move particles in an exhaust stream onto collector plates. Electrodes in the center of the flow are maintained at high voltage and generate an electrical field forcing particles to the collector walls. In dry ESPs, the collectors are knocked by various mechanical means to dislodge the particulate, which slides downward into a hopper.

This control applies to wood pulp and paper product operations.

Affected SCC:

30700101 Pulp and Paper and Wood Products, Sulfate Pulping, Digester Relief & Blow Tank
30700102 Pulp and Paper and Wood Products, Sulfate (Kraft) Pulping, Washer/Screens
30700103 Pulp and Paper and Wood Products, Sulfate (Kraft) Pulping, Multi-effect Evaporator
30700104 Pulp, Paper & Wood, Sulfate Pulping, Recovery Furnace/Direct Contact Evaporator
30700105 Pulp and Paper and Wood Products, Sulfate (Kraft) Pulping, Smelt Dissolving Tank
30700106 Pulp and Paper and Wood Products, Sulfate (Kraft) Pulping, Lime Kiln
30700108 Sulfate (Kraft) Pulping, Fluid Bed Calciner
30700109 Sulfate (Kraft) Pulping, Liquor Oxidation Tower
30700110 Sulfate (Kraft) Pulping, Recovery Furnace/Indirect Contact Evaporator
30700118 Sulfate (Kraft) Pulping, Liquor Clarifiers
30700121 Sulfate (Kraft) Pulping, Wastewater: General
30700122 Sulfate (Kraft) Pulping, Causticizing: General
30700199 Pulp and Paper and Wood Products, Sulfate (Kraft) Pulping, Other Not Classified

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: PM10 control efficiency is 98% from uncontrolled; PM2.5 control efficiency is 95% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs for ESPs of conventional design under typical operating conditions are developed using EPA cost estimating spreadsheets (EPA, 1996). When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan, 2001).

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative

AT-A-GLANCE TABLE FOR POINT SOURCES

costs was estimated as 4 percent of the total capital investment (EPA, 1999). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$15 to \$50 per scfm
Typical value is \$27 per scfm

O&M Costs:

Range from \$4 to \$40 per scfm
Typical value is \$16 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for ESP (EPA, 1996). O&M costs were calculated for three model plants with flow rates of 200 and 500 thousand acfm and 1 million acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust loading of 6.0 grains per cubic feet. The operating time was assumed to be 8640 hours per year. The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.067	\$/kW-hr
Dust disposal	25	\$/ton disposed

Note: All costs are in 1995 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$40 to \$250 per ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$110 per ton PM10 reduced. (1995\$)

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

In the wire-plate ESP, the gas flows around vertical, metal plates. The electrodes are long, weighted wires hanging between the plates. The voltage applied to the electrodes causes the gas between the electrodes to break down, known as a "corona." The electrodes are most often given a negative polarity because a negative corona supports a higher voltage than a positive corona.

AT-A-GLANCE TABLE FOR POINT SOURCES

Certain types of losses affect control efficiency. The dislodging of the accumulated layer also projects some of the particles back into the gas stream. These particles are processed in later sections of the ESP, but the particles from the last section have no chance to be recaptured. Due to the space needed at the top of the ESP for nonelectrified components, part of the stream may flow around the charged zones. This is called "sneakage" and places an upper limit on the collection efficiency of the ESP. Anti-sneakage baffles are used to force the sneakage flow to mix with the main gas stream for collection in later sections (EPA, 1998).

Another factor in the performance of ESPs is the resistivity of the collected material. All the ion current must pass through the collected layer to reach the ground plates. This creates an electric field in the layer, and it can become large enough to cause electrical breakdown. When this occurs, new ions of the wrong polarity are injected into the wire-plate gap reducing the charge on the particles, which may cause sparking. This condition is called "back corona." When this happens the collection ability of the unit is reduced. At low resistivities the particles are held on the plates so loosely that reentrainment levels are much higher. Hence, care must be taken in measuring or estimating resistivity because it is strongly affected by such variables as temperature, moisture, gas composition, particle composition, and surface characteristics (EPA, 1999).

Dusts with high resistivities are also not well-suited for collection in dry ESPs. These particles are not easily charged nor easily collected. High-resistivity particles form ash layers with very high voltage gradients on the collecting electrodes lead to back corona, reducing the charge on particles and lowering collection efficiency. Fly ash from the combustion of low-sulfur coal typically has a high resistivity, and thus is difficult to collect using dry ESPs (EPA, 1999).

References:

EPA, 1996: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, EPA 453/B-96-001, Research Triangle Park, NC. February 1996.

EPA, 1998: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October 1998.

EPA, 1999: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Dry Electrostatic Precipitator (ESP) - Wire-Plate Type," May 1999.

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Wood Pulp & Paper

Control Measure Name: Wet ESP - Wire Plate Type

Rule Name: Not Applicable

Pechan Measure Code: P2242

POD: 224

Application: This control is the use of a wire-plate type electrostatic precipitator (ESP) to reduce PM emissions. An ESP uses electrical forces to move particles in an exhaust stream onto collector plates. Electrodes in the center of the flow are maintained at high voltage and generate an electrical field forcing particles to the collector walls. Wet ESPs use a stream of water, in place of rapping mechanisms, to dislodge particulate from the plates and into a sump..

This control measure applies wood pulp and paper processing and production operations.

Affected SCC:

30700101 Pulp and Paper and Wood Products, Sulfate Pulping, Digester Relief & Blow Tank
30700102 Pulp and Paper and Wood Products, Sulfate (Kraft) Pulping, Washer/Screens
30700103 Pulp and Paper and Wood Products, Sulfate (Kraft) Pulping, Multi-effect Evaporator
30700104 Pulp, Paper & Wood, Sulfate Pulping, Recovery Furnace/Direct Contact Evaporator
30700105 Pulp and Paper and Wood Products, Sulfate (Kraft) Pulping, Smelt Dissolving Tank
30700106 Pulp and Paper and Wood Products, Sulfate (Kraft) Pulping, Lime Kiln
30700108 Sulfate (Kraft) Pulping, Fluid Bed Calciner
30700109 Sulfate (Kraft) Pulping, Liquor Oxidation Tower
30700110 Sulfate (Kraft) Pulping, Recovery Furnace/Indirect Contact Evaporator
30700118 Sulfate (Kraft) Pulping, Liquor Clarifiers
30700121 Sulfate (Kraft) Pulping, Wastewater: General
30700122 Sulfate (Kraft) Pulping, Causticizing: General
30700199 Pulp and Paper and Wood Products, Sulfate (Kraft) Pulping, Other Not Classified

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√*	√	√	√						

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: PM10 control efficiency is 99% from uncontrolled; PM2.5 control efficiency is 95% from uncontrolled

Equipment Life: 20 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The following are cost ranges for wire-plate ESPs, developed using EPA cost-estimating spreadsheets for dry wire-plate ESPs with adjustments made to reflect wet wire-plate ESPs (EPA, 1999). Capital and operating costs are generally higher due to noncorrosive materials requirements, increased water usage, and treatment and disposal of wet effluent. When stack gas flow rate data was available, the costs and cost effectiveness were calculated using the typical values of capital and O&M costs. When stack gas flow rate data was not available, default typical capital and O&M cost values based on a tons per year of PM10 removed were used (Pechan,2001).

AT-A-GLANCE TABLE FOR POINT SOURCES

Total annualized costs were determined by adding the annualized O&M costs, fixed capital recovery charges, and a fixed annual charge for taxes, insurance and administrative costs. The fixed annual charge for taxes, insurance and administrative costs was estimated as 4 percent of the total capital investment (EPA, 1990). Total installed capital costs were annualized using a capital recovery factor, with is based on a 7 percent discount rate and the expected life of the control equipment (20 years) (Pechan, 2001).

The range of high and low capital costs and O&M costs presented in the fact sheets were calculated based on the OAQPS Control Cost Manual and associated spreadsheets (EPA, 1996). The low costs in the ranges below are representative of equipment sized based on the maximum flow rate recommended in the cost manual, with no exotic materials. The high costs in the ranges below are representative of equipment sized based on the minimum flow rate recommended in the cost manual, with not exotic materials. No optional pre- or post treatment equipment costs are included.

Capital Costs:

Range from \$30 to \$60 per scfm
Typical value is \$40 per scfm

O&M Costs:

Range from \$6 to \$45 per scfm
Typical value is \$19 per scfm

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's cost-estimating spreadsheet for ESP (EPA, 1999). O&M costs were calculated for three model plants with flow rates of 10, 15 and 20 thousand acfm. The average percentage of the total O&M cost was then calculated for each O&M cost component. All the model plants were assumed to have a dust loading of 6.0 grains per cubic feet. The operating time was assumed to be 8640 hours per year. A water flow rate for the ESP was assumed to be 5 gal/min per thousand acfm. The following assumptions apply to the cost of utilities and disposal:

Electricity price	0.067	\$/kW-hr
Process water price	0.20	\$/1000 gal
Dust disposal	20	\$/ton disposed
Wastewater treatment	1.5	\$/ thousand gal treated

Note: All costs are in 1995 dollars.

Cost Effectiveness: When stack flow is available the cost effectiveness varies from \$55 to \$550 per ton PM10 removed, depending on stack flow. The default cost effectiveness value, used when stack flow is not available, is \$220 per ton PM10 reduced. (1995\$)

Comments:

Status: Demonstrated

Last Reviewed: 2001

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

Costs can be substantially higher than in the ranges shown for pollutants which require an unusually high level of control, or which require the ESP to be constructed of special materials such as titanium (EPA, 1999). In most cases, smaller units controlling a low concentration waste stream will not be as cost effective as a large unit cleaning a high pollutant load flow (EPA, 1998).

In the wire-plate ESP, the gas flows around vertical, metal plates. The electrodes are long, weighted wires hanging between the plates. The voltage applied to the electrodes causes the gas between the electrodes to break down, known as a "corona." The electrodes are most often given a negative polarity because a negative corona supports a higher voltage than a positive corona.

Certain types of losses affect control efficiency. The dislodging of the accumulated layer also projects some of the particles back into the gas stream. These particles are processed in later sections of the ESP, but the particles from the last section have no chance to be recaptured. Due to the space needed at the top of the ESP for nonelectrified components, part of the stream may flow around the charged zones. This is called "sneakage" and places an upper limit on the collection efficiency of the ESP. Anti-sneakage baffles are used to force the sneakage flow to mix with the main gas stream for collection in later sections (EPA, 1998).

Wire-Plate Type Wet ESPs require a source of wash water near the top of the collector plates. This wash system replaces the rapping mechanism used by dry ESPs. The water flows with the collected particles into a sump from which the fluid is pumped or drained. A portion of the fluid may be recycled to reduce the total amount of water required. The remainder is pumped into a settling pond or passed through a dewatering stage, with subsequent disposal of the sludge (AWMA, 1992).

Unlike dry ESPs, resistivity of the collected material is not a major factor in performance. Because of the high humidity in a wet ESP, the resistivity of particles is lowered, eliminating the "back corona" condition. The frequent washing of the plates also limits particle buildup on the collectors (EPA, 1998).

For wet ESPs, the handling wastewaters must be considered (EPA, 1999). For simple systems with innocuous dusts, water with particles collected by the ESP may be discharged from the ESP system to a solids-removing clarifier. More complicated systems may require skimming and sludge removal, clarification in dedicated equipment, pH adjustment, and/or treatment to remove dissolved solids. Recirculation of treated water to the ESP may approach 100 percent (AWMA, 1992).

References:

AWMA, 1992: Air & Waste Management Association, Air Pollution Engineering Manual, Van Nostrand Reinhold, New York.

EPA, 1996: U.S. EPA, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, EPA 453/B-96-001, Research Triangle Park, NC. February.

EPA, 1998: U.S. EPA, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October.

EPA, 1999: U.S. Environmental Protection Agency, Center on Air Pollution, "Air Pollution Technology Fact Sheet - Wet Electrostatic Precipitator (ESP) - Wire-Plate Type," May 1999

Pechan, 2001: E.H. Pechan & Associates, Inc. "Revisions to AirControlNET and Particulate Matter Control Strategies and Cost Analyses" prepared for U.S. Environmental Protection Agency,

AT-A-GLANCE TABLE FOR POINT SOURCES

Innovative Strategies and Economics Group, Research Triangle Park, NC, September 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Bituminous/Subbituminous Coal

Control Measure Name: Flue Gas Desulfurization

Rule Name: Not Applicable

Pechan Measure Code: S1901

POD: 19

Application: This control is the use of flue gas desulfurization technologies to reduce SO₂ emissions.

This control applies to industrial bituminous/subbituminous fired operations. Emissions from these sources are classified under SCCs beginning with 102002.

Affected SCC:

10200201 Industrial, Bituminous/Subbituminous Coal, Pulverized Coal: Wet Bottom
10200202 Industrial, Bituminous/Subbituminous Coal, Pulverized Coal: Dry Bottom
10200203 Industrial, Bituminous/Subbituminous Coal, Cyclone Furnace
10200204 Industrial, Bituminous/Subbituminous Coal, Spreader Stoker
10200205 Industrial, Bituminous/Subbituminous Coal, Overfeed Stoker
10200206 Industrial, Bituminous/Subbituminous Coal, Underfeed Stoker
10200210 Industrial, Bituminous/Subbituminous Coal, Overfeed Stoker **
10200212 Bituminous/Subbituminous Coal, Pulverized Coal: Dry Bottom (Tangential)
10200217 Bituminous/Subbituminous Coal, Atm. Fluidized Bed Combustion-Bubbling (Bituminous)
10200219 Bituminous/Subbituminous Coal, Cogeneration (Bituminous Coal)
10200221 Bituminous/Subbituminous Coal, Pulverized Coal: Wet Bottom (Subbituminous Coal)
10200222 Bituminous/Subbituminous Coal, Pulverized Coal: Dry Bottom (Subbituminous Coal)
10200224 Industrial, Bituminous/Subbituminous Coal, Spreader Stoker (Subbituminous Coal)
10200225 Bituminous/Subbituminous Coal, Traveling Grate (Overfeed) Stoker (Subbituminous)
10200226 Bituminous/Subbituminous Coal, Pulverized-Dry Bottom Tangential (Subbituminous)

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
							√*			

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 90% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs are based on data for FGD scrubber cost assumptions for utility boilers with a 3 percent coal sulfur content (Pechan, 1997). The assumptions apply to capacities at or above 500 megawatts (MW) [approximately 1,000,000 actual cubic feet per minute (acfm)]. For smaller sizes, the costs are scaled down using the standard 0.6 power law. The costs are based on stack flowrate in cubic feet per minute.

Cost equations for flue gas desulfurization:

Capital cost:

DEF = de-escalation factor (to convert to 1990 dollars) = 0.9383

AT-A-GLANCE TABLE FOR POINT SOURCES

RF = retrofit factor = 1.1

For stack flowrate less than 1,028,000 cu. ft./min =
 $(1,028,000/\text{Flowrate})^{0.6} * 93.3 * \text{RF} * \text{Flowrate} * \text{DEF}$

For stack flowrate greater than or equal to 1,028,000 cu. ft./min =
 $93.3 * \text{RF} * \text{Flowrate} * \text{DEF}$

Operating and Maintenance (O&M) cost = $3.35 + 0.000729 * 8736 * \text{DEF} * \text{Flowrate}$

Equipment Life in Years = Equiplife = 15 years

Interest Rate = i = 7%

Capital Recovery Factor: $\text{CRF} = [i(1+i)^{\text{Equiplife}}] / [(1+i)^{\text{Equiplife}} - 1]$

Annual cost = (Capital cost * CRF) + O&M cost

O&M Cost Components: The percentages of each O&M cost component were developed using a modified version of EPA's CUE Cost program (EPA, 2000). O&M costs were calculated for a model plant with a flowrate of 800,000 acfm. The percentage of the total O&M cost was then calculated for each O&M cost component. A credit for the sale of by-product was subtracted from the disposal costs. A capacity factor of 65% was assumed. The following assumptions apply to the cost of utilities and disposal:

Calcium Carbonate	15	\$/ton
Dibasic acid	430	\$/ton
Disposal by gypsum stacking	6	\$/ton
Disposal by landfill	30	\$/ton
Credit for by-product	2	\$/ton
Steam	3.5	\$/1000 lb
Electrical energy	25	mills/kWh

The cost effectiveness is determined by dividing the annual cost by the annual tons SO₂ reduced.

Cost Effectiveness: The cost effectiveness is variable depending on stack flow rate in cubic feet per minute.

Comments:

Status: Demonstrated

Last Reviewed: 1999

Additional Information:

FGD scrubbers can be either wet or dry systems. In wet systems, a liquid sorbent is sprayed into the flue gas in an absorber vessel. Limestone and lime-based reagents are most frequently used in scrubbers in the United States (EPA, 1981). Dry and semi-dry FGD systems include spray dryers, and dry injection into a duct or a combustion zone.

References:

EPA, 1981: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Control Techniques for Sulfur Oxide Emissions from Stationary Sources," Second Edition, Research Triangle Park, NC, April 1981.

AT-A-GLANCE TABLE FOR POINT SOURCES

EPA, 2000: U.S. Environmental Protection Agency, Office of Research and Development, "Coal Utility Environmental Cost (CUECost) Version 3.0" [computer program], February 2000.

Pechan, 1997: E.H. Pechan & Associates, Inc., "Additional Control Measure Evaluation for the Integrated Implementation of the Ozone and Particulate Matter National Ambient Air Quality Standards, and Regional Haze Program," prepared for the U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, July 17, 1997.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Bituminous/Subbituminous Coal

Control Measure Name: Flue Gas Desulfurization

Rule Name: Not Applicable

Pechan Measure Code: S2101

POD: 21

Application: This control is the use of flue gas desulfurization technologies to reduce SO₂ emissions.

This control applies to commercial/institutional bituminous/subbituminous fired operations. Emissions from these sources are classified under SCCs beginning with 103002.

Affected SCC:

10300205 Bituminous/Subbituminous Coal, Pulverized Coal: Wet Bottom (Bituminous Coal)
10300206 Commercial/Institutional, Pulverized Coal-Dry Bottom (Bituminous Coal)
10300207 Commercial/Institutional, Overfeed Stoker (Bituminous Coal)
10300208 Commercial/Institutional, Underfeed Stoker (Bituminous Coal)
10300209 Commercial/Institutional, Spreader Stoker (Bituminous Coal)
10300211 Commercial/Institutional, Bituminous/Subbituminous Coal, Overfeed Stoker **
10300217 Commercial/Institutional, Atm. Fluidized Bed Combustion-Bubbling (Bituminous Coal)
10300222 Bituminous/Subbituminous Coal, Pulverized Coal: Dry Bottom (Subbituminous Coal)
10300223 Bituminous/Subbituminous Coal, Cyclone Furnace (Subbituminous Coal)
10300224 Bituminous/Subbituminous Coal, Spreader Stoker (Subbituminous Coal)
10300225 Bituminous/Subbituminous Coal, Traveling Grate (Overfeed) Stoker (Subbituminous)
10300226 Bituminous/Subbituminous Coal, Pulverized Coal-Dry Bottom Tangential (Subbituminous)

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
							√*			

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 90% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs are based on data for FGD scrubber cost assumptions for utility boilers with a 3 percent coal sulfur content (Pechan, 1997). The assumptions apply to capacities at or above 500 megawatts (MW) [approximately 1,000,000 actual cubic feet per minute (acfm)]. For smaller sizes, the costs are scaled down using the standard 0.6 power law. The costs are based on stack flowrate in cubic feet per minute.

Cost equations for flue gas desulfurization:

Capital cost:

DEF = de-escalation factor (to convert to 1990 dollars) = 0.9383

RF = retrofit factor = 1.1

AT-A-GLANCE TABLE FOR POINT SOURCES

For stack flowrate less than 1,0280,000 cu. ft./min =
 $(1,0280,000/\text{Flowrate})^{0.6} * 93.3 * \text{RF} * \text{Flowrate} * \text{DEF}$

For stack flowrate greater than or equal to 1,0280,000 cu. ft./min =
 $93.3 * \text{RF} * \text{Flowrate} * \text{DEF}$

Operating and Maintenance (O&M) cost = $3.35 + 0.000729 * 8736 * \text{DEF} * \text{Flowrate}$

Equipment Life in Years = Equiplife = 15 years

Interest Rate = $i = 7\%$

Capital Recovery Factor: $\text{CRF} = [i (1 + i)^{\text{Equiplife}}] / [(1 + i)^{\text{Equiplife}} - 1]$

Annual cost = (Capital cost * CRF) + O&M cost

O&M Cost Components: The percentages of each O&M cost component were developed using a modified version of EPA's CUE Cost program (EPA, 2000). O&M costs were calculated for a model plant with a flowrate of 800,000 acfm. The percentage of the total O&M cost was then calculated for each O&M cost component. A credit for the sale of by-product was subtracted from the disposal costs. A capacity factor of 65% was assumed. The following assumptions apply to the cost of utilities and disposal:

Calcium Carbonate	15	\$/ton
Dibasic acid	430	\$/ton
Disposal by gypsum stacking	6	\$/ton
Disposal by landfill	30	\$/ton
Credit for by-product	2	\$/ton
Steam	3.5	\$/1000 lb
Electrical energy	25	mills/kWh

The cost effectiveness is determined by dividing the annual cost by the annual tons SO₂ reduced.

Cost Effectiveness: The cost effectiveness is variable depending on stack flow rate in cubic feet per minute.

Comments:

Status: Demonstrated

Last Reviewed: 1999

Additional Information:

FGD scrubbers can be either wet or dry systems. In wet systems, a liquid sorbent is sprayed into the flue gas in an absorber vessel. Limestone and lime-based reagents are most frequently used in scrubbers in the United States (EPA, 1981). Dry and semi-dry FGD systems include spray dryers, and dry injection into a duct or a combustion zone.

References:

EPA, 1981: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Control Techniques for Sulfur Oxide Emissions from Stationary Sources," Second Edition, Research Triangle Park, NC, April 1981.

EPA, 2000: U.S. Environmental Protection Agency, Office of Research and Development, "Coal Utility Environmental Cost (CUECost) Version 3.0" [computer program], February 2000.

AT-A-GLANCE TABLE FOR POINT SOURCES

Pechan, 1997: E.H. Pechan & Associates, Inc., "Additional Control Measure Evaluation for the Integrated Implementation of the Ozone and Particulate Matter National Ambient Air Quality Standards, and Regional Haze Program," prepared for the U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, July 17, 1997.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Bituminous/Subbituminous Coal (Industrial Boilers)

Control Measure Name: In-duct Dry Sorbent Injection

Rule Name: Not Applicable

Pechan Measure Code: S3000

POD: 19

Application: Two types of dry sorbents were injected into the ductwork downstream of the boiler to reduce SO₂ emissions. Either calcium-based sorbent was injected upstream of the economizer, or sodium-based sorbent downstream of the air heater. Humidification downstream of the dry sorbent injection was incorporated to aid SO₂ capture and lower flue gas temperature and gas flow before entering the fabric filter dust collector (FFDC).

Affected SCC:

10200201 Industrial, Bituminous/Subbituminous Coal, Pulverized Coal: Wet Bottom
10200202 Industrial, Bituminous/Subbituminous Coal, Pulverized Coal: Dry Bottom
10200203 Industrial, Bituminous/Subbituminous Coal, Cyclone Furnace
10200204 Industrial, Bituminous/Subbituminous Coal, Spreader Stoker
10200205 Industrial, Bituminous/Subbituminous Coal, Overfeed Stoker
10200206 Industrial, Bituminous/Subbituminous Coal, Underfeed Stoker
10200210 Industrial, Bituminous/Subbituminous Coal, Overfeed Stoker **
10200212 Bituminous/Subbituminous Coal, Pulverized Coal: Dry Bottom (Tangential)
10200217 Bituminous/Subbituminous Coal, Atm. Fluidized Bed Combustion-Bubbling (Bituminous)
10200219 Bituminous/Subbituminous Coal, Cogeneration (Bituminous Coal)
10200221 Bituminous/Subbituminous Coal, Pulverized Coal: Wet Bottom (Subbituminous Coal)
10200222 Bituminous/Subbituminous Coal, Pulverized Coal: Dry Bottom (Subbituminous Coal)
10200224 Industrial, Bituminous/Subbituminous Coal, Spreader Stoker (Subbituminous Coal)
10200225 Bituminous/Subbituminous Coal, Traveling Grate (Overfeed) Stoker (Subbituminous)
10200226 Bituminous/Subbituminous Coal, Pulverized-Dry Bottom Tangential (Subbituminous)

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
							√*			

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 40% from uncontrolled

Equipment Life: 30 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: In general, an EPRI methodology was used for the cost estimates, with the following cost factor is used for the non-process costs:

General Facilities: 5% of total direct process cost

Engineering and home office fees: 10% of total direct process cost

Process contingency: 5% of total direct process cost

Project contingency: 15% of total direct process and the above three non-process costs

Retrofit Factor: 30%

Preproduction cost: 2% of total plant investment with retrofit costs

Inventory Capital: cost for a 30-day reagent storage

AT-A-GLANCE TABLE FOR POINT SOURCES

The levelized costs (\$/ton of SO₂ removed) were calculated using the estimates of the capital costs and increased consumable rates associated with each technology. The costs are based on 1999 dollars. The economic factors used in these calculation were as follows:

Lime: \$ 50 / ton
Limestone: \$15 /ton
Water: \$0.0006 / gal
Solid Waste Disposal: \$12 / ton
Operator Cost: \$ 30 /hr
Useful life: 30 years
Carrying charges: 12%
Levelization factor: 1
Maintenance cost (% of capital cost): 2.0 for IDIS and SDA

Cost Effectiveness: Cost effectiveness is the fuction of boiler capacity. Following cost per ton (1999\$) is used depending on the boiler capacity.

For Boilers ,
< 100 MMBtu/hr - \$2,107 per ton SO₂ reduced
> 100 MMBtu/hr and < 250 MMBtu/hr - \$1,526 per ton SO₂ reduced
> 250 MMBtu/hr - \$1,111 / ton of SO₂ reduced

Comments:

Status: Demonstrated

Last Reviewed:

Additional Information:

References:

EPA, 2003: U.S. Environmental Protection Agency: "Methdology, Assumptions, and References Preliminary SO₂ Controls Cost Estimates For Industrial Boilers", October 2003.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Bituminous/Subbituminous Coal (Industrial Boilers)

Control Measure Name: Spray Dryer Absorber

Rule Name: Not Applicable

Pechan Measure Code: S3001

POD: 19

Application: Two types of dry sorbents were injected into the ductwork downstream of the boiler to reduce SO₂ emissions. Either calcium-based sorbent was injected upstream of the economizer, or sodium-based sorbent downstream of the air heater. Humidification downstream of the dry sorbent injection was incorporated to aid SO₂ capture and lower flue gas temperature and gas flow before entering the fabric filter dust collector (FFDC).

Affected SCC:

10200201 Industrial, Bituminous/Subbituminous Coal, Pulverized Coal: Wet Bottom
10200202 Industrial, Bituminous/Subbituminous Coal, Pulverized Coal: Dry Bottom
10200203 Industrial, Bituminous/Subbituminous Coal, Cyclone Furnace
10200204 Industrial, Bituminous/Subbituminous Coal, Spreader Stoker
10200205 Industrial, Bituminous/Subbituminous Coal, Overfeed Stoker
10200206 Industrial, Bituminous/Subbituminous Coal, Underfeed Stoker
10200210 Industrial, Bituminous/Subbituminous Coal, Overfeed Stoker **
10200212 Bituminous/Subbituminous Coal, Pulverized Coal: Dry Bottom (Tangential)
10200217 Bituminous/Subbituminous Coal, Atm. Fluidized Bed Combustion-Bubbling (Bituminous)
10200219 Bituminous/Subbituminous Coal, Cogeneration (Bituminous Coal)
10200221 Bituminous/Subbituminous Coal, Pulverized Coal: Wet Bottom (Subbituminous Coal)
10200222 Bituminous/Subbituminous Coal, Pulverized Coal: Dry Bottom (Subbituminous Coal)
10200224 Industrial, Bituminous/Subbituminous Coal, Spreader Stoker (Subbituminous Coal)
10200225 Bituminous/Subbituminous Coal, Traveling Grate (Overfeed) Stoker (Subbituminous)
10200226 Bituminous/Subbituminous Coal, Pulverized-Dry Bottom Tangential (Subbituminous)

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
							√*			

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 90% from uncontrolled

Equipment Life: 30 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: In general, an EPRI methodology was used for the cost estimates, with the following cost factor is used for the non-process costs:

General Facilities: 5% of total direct process cost

Engineering and home office fees: 10% of total direct process cost

Process contingency: 5% of total direct process cost

Project contingency: 15% of total direct process and the above three non-process costs

Retrofit Factor: 30%

Preproduction cost: 2% of total plant investment with retrofit costs

Inventory Capital: cost for a 30-day reagent storage

AT-A-GLANCE TABLE FOR POINT SOURCES

The levelized costs (\$/ton of SO₂ removed) were calculated using the estimates of the capital costs and increased consumable rates associated with each technology. The costs are based on 1999 dollars. The economic factors used in these calculation were as follows:

Lime: \$ 50 / ton
Limestone: \$15 /ton
Water: \$0.0006 / gal
Solid Waste Disposal: \$12 / ton
Operator Cost: \$ 30 /hr
Useful life: 30 years
Carrying charges: 12%
Levelization factor: 1
Maintenance cost (% of capital cost): 2.0 for IDIS and SDA

Cost Effectiveness: Cost effectiveness is the fuction of boiler capacity. Following cost per ton (1999\$) is used depending on the boiler capacity.

For Boilers ,
< 100 MMBtu/hr - \$1,973 per ton SO₂ reduced
> 100 MMBtu/hr and < 250 MMBtu/hr - \$1,340 per ton SO₂ reduced
> 250 MMBtu/hr - \$804 / ton of SO₂ reduced

Comments:

Status: Demonstrated

Last Reviewed: 2005

Additional Information:

References:

EPA, 2003: U.S. Environmental Protection Agency: "Methdology, Assumptions, and References Preliminary SO₂ Controls Cost Estimates For Industrial Boilers", October 2003.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Bituminous/Subbituminous Coal (Industrial Boilers)

Control Measure Name: Wet Flue Gas Desulfurization

Rule Name: Not Applicable

Pechan Measure Code: S3002

POD: 19

Application: Two types of dry sorbents were injected into the ductwork downstream of the boiler to reduce SO₂ emissions. Either calcium-based sorbent was injected upstream of the economizer, or sodium-based sorbent downstream of the air heater. Humidification downstream of the dry sorbent injection was incorporated to aid SO₂ capture and lower flue gas temperature and gas flow before entering the fabric filter dust collector (FFDC).

Affected SCC:

10200201 Industrial, Bituminous/Subbituminous Coal, Pulverized Coal: Wet Bottom
10200202 Industrial, Bituminous/Subbituminous Coal, Pulverized Coal: Dry Bottom
10200203 Industrial, Bituminous/Subbituminous Coal, Cyclone Furnace
10200204 Industrial, Bituminous/Subbituminous Coal, Spreader Stoker
10200205 Industrial, Bituminous/Subbituminous Coal, Overfeed Stoker
10200206 Industrial, Bituminous/Subbituminous Coal, Underfeed Stoker
10200210 Industrial, Bituminous/Subbituminous Coal, Overfeed Stoker **
10200212 Bituminous/Subbituminous Coal, Pulverized Coal: Dry Bottom (Tangential)
10200217 Bituminous/Subbituminous Coal, Atm. Fluidized Bed Combustion-Bubbling (Bituminous)
10200219 Bituminous/Subbituminous Coal, Cogeneration (Bituminous Coal)
10200221 Bituminous/Subbituminous Coal, Pulverized Coal: Wet Bottom (Subbituminous Coal)
10200222 Bituminous/Subbituminous Coal, Pulverized Coal: Dry Bottom (Subbituminous Coal)
10200224 Industrial, Bituminous/Subbituminous Coal, Spreader Stoker (Subbituminous Coal)
10200225 Bituminous/Subbituminous Coal, Traveling Grate (Overfeed) Stoker (Subbituminous)
10200226 Bituminous/Subbituminous Coal, Pulverized-Dry Bottom Tangential (Subbituminous)

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
							√*			

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 90% from uncontrolled

Equipment Life: 30 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: In general, an EPRI methodology was used for the cost estimates, with the following cost factor is used for the non-process costs:

General Facilities: 5% of total direct process cost
Engineering and home office fees: 10% of total direct process cost
Process contingency: 5% of total direct process cost
Project contingency: 15% of total direct process and the above three non-process costs
Retrofit Factor: 30%
Preproduction cost: 2% of total plant investment with retrofit costs
Inventory Capital: cost for a 30-day reagent storage

AT-A-GLANCE TABLE FOR POINT SOURCES

The levelized costs (\$/ton of SO₂ removed) were calculated using the estimates of the capital costs and increased consumable rates associated with each technology. The costs are based on 1999 dollars. The economic factors used in these calculation were as follows:

Lime: \$ 50 / ton
Limestone: \$15 /ton
Water: \$0.0006 / gal
Solid Waste Disposal: \$12 / ton
Operator Cost: \$ 30 /hr
Useful life: 30 years
Carrying charges: 12%
Levelization factor: 1
Maintenance cost (% of capital cost): 3.0 for FGD

Cost Effectiveness: Cost effectiveness is the fuction of boiler capacity. Following cost per ton (1999\$) is used depending on the boiler capacity.

For Boilers ,
< 100 MMBtu/hr - \$1,980 per ton SO₂ reduced
> 100 MMBtu/hr and < 250 MMBtu/hr - \$1,535 per ton SO₂ reduced
> 250 MMBtu/hr - \$1,027 / ton of SO₂ reduced

Comments:

Status:

Last Reviewed: 2005

Additional Information:

References:

EPA, 2003: U.S. Environmental Protection Agency: "Methdology, Assumptions, and References Preliminary SO₂ Controls Cost Estimates For Industrial Boilers", October 2003.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: By-Product Coke Manufacturing

Control Measure Name: Vacuum Carbonate Plus Sulfur Recovery Plant

Rule Name: Not Applicable

Pechan Measure Code: S1201

POD: 12a

Application: This control is the use of vacuum carbonate to reduce SO₂ emissions.

This control applies to by-product coke manufacturing operations. Emissions are classified under SCCs beginning with 303003.

Affected SCC:

30300302 Primary Metal Production, By-product Coke Manufacturing, Oven Charging
30300303 By-product Coke Manufacturing, Oven Pushing
30300304 By-product Coke Manufacturing, Quenching
30300306 By-product Coke Manufacturing, Oven Underfiring
30300308 By-product Coke Manufacturing, Oven/Door Leaks
30300313 By-product Coke Manufacturing, Coal Preheater
30300314 By-product Coke Manufacturing, Topside Leaks
30300315 Primary Metal Production, By-product Coke Manufacturing, Gas By-product Plant

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
							√*			

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 82% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs are based on stack flowrate in cubic feet per minute. The equations below are simplified from the EPA Control Cost Manual (EPA, 2002).

It is assumed that costs for vacuum carbonate controls are similar to costs for flue gas desulfurization.

Cost equations for flue gas desulfurization:

Capital cost:

DEF = de-escalation factor (to convert to 1990 dollars) = 0.9383

RF = retrofit factor = 1.1

For stack flowrate less than 1,0280,000 cu. ft./min =
 $(1,0280,000/\text{Flowrate})^{0.6} \times 93.3 \times \text{RF} \times \text{Flowrate} \times \text{DEF}$

For stack flowrate greater than or equal to 1,0280,000 cu. ft./min =
 $93.3 \times \text{RF} \times \text{Flowrate} \times \text{DEF}$

Operating and Maintenance (O&M) cost = $3.35 + 0.000729 \times 8736 \times \text{DEF} \times \text{Flowrate}$

AT-A-GLANCE TABLE FOR POINT SOURCES

Equipment Life in Years = Equiplife = 15 years

Interest Rate = i = 7%

Capital Recovery Factor: $CRF = [i(1+i)^{Equiplife}] / [(1+i)^{Equiplife} - 1]$

Annual cost = (Capital cost * CRF) + O&M cost

The cost effectiveness is determined by dividing the annual cost by the annual tons SO₂ reduced.

Cost Effectiveness: The cost effectiveness is variable depending on stack flow rate in cubic feet per minute.

Comments:

Status: Demonstrated

Last Reviewed: 1999

Additional Information:

FGD scrubbers can be either wet or dry systems. In wet systems, a liquid sorbent is sprayed into the flue gas in an absorber vessel. Limestone and lime-based reagents are most frequently used in scrubbers in the United States (EPA, 2002). Dry and semi-dry FGD systems include spray dryers, and dry injection into a duct or a combustion zone.

References:

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Distillate Oil (Industrial Boiler)

Control Measure Name: Wet Flue Gas Desulfurization

Rule Name: Not Applicable

Pechan Measure Code: S3007

POD: 30

Application: Two types of dry sorbents were injected into the ductwork downstream of the boiler to reduce SO₂ emissions. Either calcium-based sorbent was injected upstream of the economizer, or sodium-based sorbent downstream of the air heater. Humidification downstream of the dry sorbent injection was incorporated to aid SO₂ capture and lower flue gas temperature and gas flow before entering the fabric filter dust collector (FFDC).

Affected SCC:

10200501 Industrial, Distillate Oil, Grades 1 and 2
Oil

10200502 Industrial, Distillate

Oil, 10-100 Million Btu/hr

10200503 Industrial, Distillate Oil, < 10 Million
Btu/hr

10200504 Industrial, Distillate Oil, Grade 4

10200505 Industrial, Distillate

Oil

Oil, Cogeneration

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
							√*			

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 90% from uncontrolled

Equipment Life: 30 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: In general, an EPRI methodology was used for the cost estimates, with the following cost factor is used for the non-process costs:

General Facilities: 5% of total direct process cost

Engineering and home office fees: 10% of total direct process cost

Process contingency: 5% of total direct process cost

Project contingency: 15% of total direct process and the above three non-process costs

Retrofit Factor: 30%

Preproduction cost: 2% of total plant investment with retrofit costs

Inventory Capital: cost for a 30-day reagent storage

The levelized costs (\$/ton of SO₂ removed) were calculated using the estimates of the capital costs and increased consumable rates associated with each technology. The costs are based on 1999 dollars. The economic factors used in these calculation were as follows:

Lime: \$ 50 / ton

AT-A-GLANCE TABLE FOR POINT SOURCES

Limestone: \$15 /ton
Water: \$0.0006 / gal
Solid Waste Disposal: \$12 / ton
Operator Cost: \$ 30 /hr
Useful life: 30 years
Carrying charges: 12%
Levelization factor: 1
Maintenance cost (% of capital cost): 3.0 for FGD

Cost Effectiveness: Cost effectiveness is the function of boiler capacity. Following cost per ton (1999\$) is used depending on the boiler capacity.

For Boilers ,
< 100 MMBtu/hr - \$4,524 per ton SO₂ reduced
> 100 MMBtu/hr and < 250 MMBtu/hr - \$3,489 per ton SO₂ reduced
> 250 MMBtu/hr - \$2,295 / ton of SO₂ reduced

Comments:

Status:	Last Reviewed: 2005
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Additional Information:

References:

EPA, 2003: U.S. Environmental Protection Agency: "Methodology, Assumptions, and References Preliminary SO₂ Controls Cost Estimates For Industrial Boilers", October 2003.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Inorganic Chemical Manufacture

Control Measure Name: Flue Gas Desulfurization

Rule Name: Not Applicable

Pechan Measure Code: S1101

POD: 11

Application: This control is the use of flue gas desulfurization technologies to reduce SO₂ emissions.

This control applies to inorganic chemical manufacture operations. Emissions from these sources are classified under SCCs 30100509 and 30199999.

Affected SCC:

30100509 Carbon Black Production, Furnace Process: Fugitive Emissions

30199999 Chemical Manufacturing, Other Not Classified, Specify in Comments Field

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
							√*			

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 90% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs are based on data for FGD scrubber cost assumptions for utility boilers with a 3 percent coal sulfur content (Pechan, 1997). The assumptions apply to capacities at or above 500 megawatts (MW) [approximately 1,000,000 actual cubic feet per minute (acfm)]. For smaller sizes, the costs are scaled down using the standard 0.6 power law. The costs are based on stack flowrate in cubic feet per minute.

Cost equations for flue gas desulfurization:

Capital cost:

DEF = de-escalation factor (to convert to 1990 dollars) = 0.9383

RF = retrofit factor = 1.1

For stack flowrate less than 1,028,000 cu. ft./min =
 $(1,028,000/\text{Flowrate})^{0.6} \times 93.3 \times \text{RF} \times \text{Flowrate} \times \text{DEF}$

For stack flowrate greater than or equal to 1,028,000 cu. ft./min =
 $93.3 \times \text{RF} \times \text{Flowrate} \times \text{DEF}$

Operating and Maintenance (O&M) cost = $3.35 + 0.000729 \times 8736 \times \text{DEF} \times \text{Flowrate}$

Equipment Life in Years = Equiplife = 15 years

Interest Rate = I = 7%

Capital Recovery Factor: $\text{CRF} = [i(1+i)^{\text{Equiplife}}] / [(1+i)^{\text{Equiplife}} - 1]$

AT-A-GLANCE TABLE FOR POINT SOURCES

Annual cost = (Capital cost * CRF) + O&M cost

O&M Cost Components: The percentages of each O&M cost component were developed using a modified version of EPA's CUE Cost program (EPA, 2000). O&M costs were calculated for a model plant with a flowrate of 800,000 acfm. The percentage of the total O&M cost was then calculated for each O&M cost component. A credit for the sale of by-product was subtracted from the disposal costs. A capacity factor of 65% was assumed. The following assumptions apply to the cost of utilities and disposal:

Calcium Carbonate	15	\$/ton
Dibasic acid	430	\$/ton
Disposal by gypsum stacking	6	\$/ton
Disposal by landfill	30	\$/ton
Credit for by-product	2	\$/ton
Steam	3.5	\$/1000 lb
Electrical energy	25	mills/kWh

The cost effectiveness is determined by dividing the annual cost by the annual tons SO₂ reduced.

Cost Effectiveness: The cost effectiveness is variable depending on stack flow rate in cubic feet per minute.

Comments:

Status: Demonstrated

Last Reviewed: 1999

Additional Information:

FGD scrubbers can be either wet or dry systems. In wet systems, a liquid sorbent is sprayed into the flue gas in an absorber vessel. Limestone and lime-based reagents are most frequently used in scrubbers in the United States (EPA, 1981). Dry and semi-dry FGD systems include spray dryers, and dry injection into a duct or a combustion zone.

References:

EPA, 1981: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Control Techniques for Sulfur Oxide Emissions from Stationary Sources," Second Edition, Research Triangle Park, NC, April 1981.

EPA, 2000: U.S. Environmental Protection Agency, Office of Research and Development, "Coal Utility Environmental Cost (CUECost) Version 3.0" [computer program], February 2000.

Pechan, 1997: E.H. Pechan & Associates, Inc., "Additional Control Measure Evaluation for the Integrated Implementation of the Ozone and Particulate Matter National Ambient Air Quality Standards, and Regional Haze Program," prepared for the U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, July 17, 1997.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: In-process Fuel Use - Bituminous Coal

Control Measure Name: Flue Gas Desulfurization

Rule Name: Not Applicable

Pechan Measure Code: S2201

POD: 22

Application: This control is the use of flue gas desulfurization technologies to reduce SO₂ emissions.

This control applies to operations with in-process bituminous coal use. Emissions from these sources are classified under SCCs 39000288, 39000289, and 39000299.

Affected SCC:

39000288 Bituminous Coal, General (Subbituminous)

39000289 Bituminous Coal, General (Bituminous)

39000299 In-process Fuel Use, Bituminous Coal, General (Bituminous)

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
							√*			

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 90% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs are based on data for FGD scrubber cost assumptions for utility boilers with a 3 percent coal sulfur content (Pechan, 1997). The assumptions apply to capacities at or above 500 megawatts (MW) [approximately 1,000,000 actual cubic feet per minute (acfm)]. For smaller sizes, the costs are scaled down using the standard 0.6 power law. The costs are based on stack flowrate in cubic feet per minute.

Cost equations for flue gas desulfurization:

Capital cost:

DEF = de-escalation factor (to convert to 1990 dollars) = 0.9383

RF = retrofit factor = 1.1

For stack flowrate less than 1,028,000 cu. ft./min =
 $(1,028,000/\text{Flowrate})^{0.6} \times 93.3 \times \text{RF} \times \text{Flowrate} \times \text{DEF}$

For stack flowrate greater than or equal to 1,028,000 cu. ft./min =
 $93.3 \times \text{RF} \times \text{Flowrate} \times \text{DEF}$

Operating and Maintenance (O&M) cost = $3.35 + 0.000729 \times 8736 \times \text{DEF} \times \text{Flowrate}$

Equipment Life in Years = Equiplife = 15 years

Interest Rate = I = 7%

AT-A-GLANCE TABLE FOR POINT SOURCES

Capital Recovery Factor: $CRF = [i(1+i)^{Equiplife}] / [(1+i)^{Equiplife} - 1]$

Annual cost = (Capital cost * CRF) + O&M cost

O&M Cost Components: The percentages of each O&M cost component were developed using a modified version of EPA's CUE Cost program (EPA, 2000). O&M costs were calculated for a model plant with a flowrate of 800,000 acfm. The percentage of the total O&M cost was then calculated for each O&M cost component. A credit for the sale of by-product was subtracted from the disposal costs. A capacity factor of 65% was assumed. The following assumptions apply to the cost of utilities and disposal:

Calcium Carbonate	15	\$/ton
Dibasic acid	430	\$/ton
Disposal by gypsum stacking	6	\$/ton
Disposal by landfill	30	\$/ton
Credit for by-product	2	\$/ton
Steam	3.5	\$/1000 lb
Electrical energy	25	mills/kWh

The cost effectiveness is determined by dividing the annual cost by the annual tons SO₂ reduced.

Cost Effectiveness: The cost effectiveness is variable depending on stack flow rate in cubic feet per minute.

Comments:

Status: Demonstrated	Last Reviewed: 1999
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Additional Information:

FGD scrubbers can be either wet or dry systems. In wet systems, a liquid sorbent is sprayed into the flue gas in an absorber vessel. Limestone and lime-based reagents are most frequently used in scrubbers in the United States (EPA, 1981). Dry and semi-dry FGD systems include spray dryers, and dry injection into a duct or a combustion zone.

References:

EPA, 1981: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Control Techniques for Sulfur Oxide Emissions from Stationary Sources," Second Edition, Research Triangle Park, NC, April 1981.

EPA, 2000: U.S. Environmental Protection Agency, Office of Research and Development, "Coal Utility Environmental Cost (CUECost) Version 3.0" [computer program], February 2000.

Pechan, 1997: E.H. Pechan & Associates, Inc., "Additional Control Measure Evaluation for the Integrated Implementation of the Ozone and Particulate Matter National Ambient Air Quality Standards, and Regional Haze Program," prepared for the U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, July 17, 1997.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Lignite (Industrial Boiler)

Control Measure Name: In-duct Dry Sorbent Injection

Rule Name: Not Applicable

Pechan Measure Code: S3003

POD: 23

Application: Two types of dry sorbents were injected into the ductwork downstream of the boiler to reduce SO₂ emissions. Either calcium-based sorbent was injected upstream of the economizer, or sodium-based sorbent downstream of the air heater. Humidification downstream of the dry sorbent injection was incorporated to aid SO₂ capture and lower flue gas temperature and gas flow before entering the fabric filter dust collector (FFDC).

Affected SCC:

10200301 Industrial, Lignite Coal, Pulverized Coal: Dry Bottom, Wall Fired
10200302 Industrial, Lignite Coal, Pulverized Coal: Dry Bottom, Tangential Fired
10200303 Industrial, Lignite Coal, Cyclone Furnace
10200304 Industrial, Lignite Coal, Traveling Grate (Overfeed) Stoker
10200306 Industrial, Lignite Coal, Spreader Stoker
10200307 Industrial, Lignite Coal, Cogeneration

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
							√*			

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 40% from uncontrolled

Equipment Life: 30 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: In general, an EPRI methodology was used for the cost estimates, with the following cost factor is used for the non-process costs:

General Facilities: 5% of total direct process cost
Engineering and home office fees: 10% of total direct process cost
Process contingency: 5% of total direct process cost
Project contingency: 15% of total direct process and the above three non-process costs
Retrofit Factor: 30%
Preproduction cost: 2% of total plant investment with retrofit costs
Inventory Capital: cost for a 30-day reagent storage

The levelized costs (\$/ton of SO₂ removed) were calculated using the estimates of the capital costs and increased consumable rates associated with each technology. The costs are based on 1999 dollars. The economic factors used in these calculation were as follows:

Lime: \$ 50 / ton
Limestone: \$15 /ton
Water: \$0.0006 / gal

AT-A-GLANCE TABLE FOR POINT SOURCES

Solid Waste Disposal: \$12 / ton
Operator Cost: \$ 30 /hr
Useful life: 30 years
Carrying charges: 12%
Levelization factor: 1
Maintenance cost (% of capital cost): 2.0 for IDIS and SDA

Cost Effectiveness: Cost effectiveness is the function of boiler capacity. Following cost per ton (1999\$) is used depending on the boiler capacity.

For Boilers ,
< 100 MMBtu/hr - \$2,107 per ton SO₂ reduced
> 100 MMBtu/hr and < 250 MMBtu/hr - \$1,526 per ton SO₂ reduced
> 250 MMBtu/hr - \$1,111 / ton of SO₂ reduced

Comments:

Status:	Last Reviewed: 2005
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Additional Information:

References:

EPA, 2003: U.S. Environmental Protection Agency: "Methodology, Assumptions, and References Preliminary SO₂ Controls Cost Estimates For Industrial Boilers", October 2003.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Lignite (Industrial Boiler)

Control Measure Name: Spray Dryer Absorber

Rule Name: Not Applicable

Pechan Measure Code: S3004

POD: 23

Application: Two types of dry sorbents were injected into the ductwork downstream of the boiler to reduce SO₂ emissions. Either calcium-based sorbent was injected upstream of the economizer, or sodium-based sorbent downstream of the air heater. Humidification downstream of the dry sorbent injection was incorporated to aid SO₂ capture and lower flue gas temperature and gas flow before entering the fabric filter dust collector (FFDC).

Affected SCC:

10200301 Industrial, Lignite Coal, Pulverized Coal: Dry Bottom, Wall Fired
10200302 Industrial, Lignite Coal, Pulverized Coal: Dry Bottom, Tangential Fired
10200303 Industrial, Lignite Coal, Cyclone Furnace
10200304 Industrial, Lignite Coal, Traveling Grate (Overfeed) Stoker
10200306 Industrial, Lignite Coal, Spreader Stoker
10200307 Industrial, Lignite Coal, Cogeneration

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
							√*			

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 90% from uncontrolled

Equipment Life: 30 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: In general, an EPRI methodology was used for the cost estimates, with the following cost factor is used for the non-process costs:

General Facilities: 5% of total direct process cost
Engineering and home office fees: 10% of total direct process cost
Process contingency: 5% of total direct process cost
Project contingency: 15% of total direct process and the above three non-process costs
Retrofit Factor: 30%
Preproduction cost: 2% of total plant investment with retrofit costs
Inventory Capital: cost for a 30-day reagent storage

The levelized costs (\$/ton of SO₂ removed) were calculated using the estimates of the capital costs and increased consumable rates associated with each technology. The costs are based on 1999 dollars. The economic factors used in these calculation were as follows:

Lime: \$ 50 / ton
Limestone: \$15 /ton
Water: \$0.0006 / gal

AT-A-GLANCE TABLE FOR POINT SOURCES

Solid Waste Disposal: \$12 / ton
Operator Cost: \$ 30 /hr
Useful life: 30 years
Carrying charges: 12%
Levelization factor: 1
Maintenance cost (% of capital cost): 2.0 for IDIS and SDA

Cost Effectiveness: Cost effectiveness is the function of boiler capacity. Following cost per ton (1999\$) is used depending on the boiler capacity.

For Boilers ,
< 100 MMBtu/hr - \$1,973 per ton SO₂ reduced
> 100 MMBtu/hr and < 250 MMBtu/hr - \$1,340 per ton SO₂ reduced
> 250 MMBtu/hr - \$804 / ton of SO₂ reduced

Comments:

Status:	Last Reviewed: 2005
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Additional Information:

References:

EPA, 2003: U.S. Environmental Protection Agency: "Methodology, Assumptions, and References Preliminary SO₂ Controls Cost Estimates For Industrial Boilers", October 2003.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Lignite (Industrial Boiler)

Control Measure Name: Wet Flue Gas Desulfurization

Rule Name: Not Applicable

Pechan Measure Code: S3005

POD: 23

Application: Two types of dry sorbents were injected into the ductwork downstream of the boiler to reduce SO₂ emissions. Either calcium-based sorbent was injected upstream of the economizer, or sodium-based sorbent downstream of the air heater. Humidification downstream of the dry sorbent injection was incorporated to aid SO₂ capture and lower flue gas temperature and gas flow before entering the fabric filter dust collector (FFDC).

Affected SCC:

10200301 Industrial, Lignite Coal, Pulverized Coal: Dry Bottom, Wall Fired
10200302 Industrial, Lignite Coal, Pulverized Coal: Dry Bottom, Tangential Fired
10200303 Industrial, Lignite Coal, Cyclone Furnace
10200304 Industrial, Lignite Coal, Traveling Grate (Overfeed) Stoker
10200306 Industrial, Lignite Coal, Spreader Stoker
10200307 Industrial, Lignite Coal, Cogeneration

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
							√*			

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 90% from uncontrolled

Equipment Life: 30 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: In general, an EPRI methodology was used for the cost estimates, with the following cost factor is used for the non-process costs:

General Facilities: 5% of total direct process cost
Engineering and home office fees: 10% of total direct process cost
Process contingency: 5% of total direct process cost
Project contingency: 15% of total direct process and the above three non-process costs
Retrofit Factor: 30%
Preproduction cost: 2% of total plant investment with retrofit costs
Inventory Capital: cost for a 30-day reagent storage

The levelized costs (\$/ton of SO₂ removed) were calculated using the estimates of the capital costs and increased consumable rates associated with each technology. The costs are based on 1999 dollars. The economic factors used in these calculation were as follows:

Lime: \$ 50 / ton
Limestone: \$15 /ton
Water: \$0.0006 / gal

AT-A-GLANCE TABLE FOR POINT SOURCES

Solid Waste Disposal: \$12 / ton
Operator Cost: \$ 30 /hr
Useful life: 30 years
Carrying charges: 12%
Levelization factor: 1
Maintenance cost (% of capital cost): 3.0 for FGD

Cost Effectiveness: Cost effectiveness is the function of boiler capacity. Following cost per ton (1999\$) is used depending on the boiler capacity.

For Boilers ,
< 100 MMBtu/hr - \$1,980 per ton SO₂ reduced
> 100 MMBtu/hr and < 250 MMBtu/hr - \$1,535 per ton SO₂ reduced
> 250 MMBtu/hr - \$1,027 / ton of SO₂ reduced

Comments:

Status:	Last Reviewed: 2005
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Additional Information:

References:

EPA, 2003: U.S. Environmental Protection Agency: "Methodology, Assumptions, and References Preliminary SO₂ Controls Cost Estimates For Industrial Boilers", October 2003.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Lignite (Industrial Boilers)

Control Measure Name: Flue Gas Desulfurization

Rule Name: Not Applicable

Pechan Measure Code: S2301

POD: 23

Application: This control is the use of flue gas desulfurization technologies to reduce SO₂ emissions.

This control applies to industrial lignite fired operations. Emissions from these sources are classified under SCCs beginning with 102003.

Affected SCC:

10200301 Lignite, Pulverized Coal: Dry Bottom, Wall Fired

10200303 Lignite, Cyclone Furnace

10200306 Lignite, Spreader Stoker

10200307 Lignite, Cogeneration

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
							√*			

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 90% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs are based on data for FGD scrubber cost assumptions for utility boilers with a 3 percent coal sulfur content (Pechan, 1997). The assumptions apply to capacities at or above 500 megawatts (MW) [approximately 1,000,000 actual cubic feet per minute (acfm)]. For smaller sizes, the costs are scaled down using the standard 0.6 power law. The costs are based on stack flowrate in cubic feet per minute.

Cost equations for flue gas desulfurization:

Capital cost:

DEF = de-escalation factor (to convert to 1990 dollars) = 0.9383

RF = retrofit factor = 1.1

For stack flowrate less than 1,028,000 cu. ft./min =
 $(1,028,000/\text{Flowrate})^{0.6} \times 93.3 \times \text{RF} \times \text{Flowrate} \times \text{DEF}$

For stack flowrate greater than or equal to 1,028,000 cu. ft./min =
 $93.3 \times \text{RF} \times \text{Flowrate} \times \text{DEF}$

Operating and Maintenance (O&M) cost = $3.35 + 0.000729 \times 8736 \times \text{DEF} \times \text{Flowrate}$

Equipment Life in Years = Equiplife = 15 years

AT-A-GLANCE TABLE FOR POINT SOURCES

Interest Rate = $i = 7\%$

Capital Recovery Factor: $CRF = [i(1+i)^{\text{Equiplife}}] / [(1+i)^{\text{Equiplife}} - 1]$

Annual cost = (Capital cost * CRF) + O&M cost

O&M Cost Components: The percentages of each O&M cost component were developed using a modified version of EPA's CUE Cost program (EPA, 2000). O&M costs were calculated for a model plant with a flowrate of 800,000 acfm. The percentage of the total O&M cost was then calculated for each O&M cost component. A credit for the sale of by-product was subtracted from the disposal costs. A capacity factor of 65% was assumed. The following assumptions apply to the cost of utilities and disposal:

Calcium Carbonate	15	\$/ton
Dibasic acid	430	\$/ton
Disposal by gypsum stacking	6	\$/ton
Disposal by landfill	30	\$/ton
Credit for by-product	2	\$/ton
Steam	3.5	\$/1000 lb
Electrical energy	25	mills/kWh

The cost effectiveness is determined by dividing the annual cost by the annual tons SO₂ reduced.

Cost Effectiveness: The cost effectiveness is variable depending on stack flow rate in cubic feet per minute.

Comments:

Status: Demonstrated

Last Reviewed: 1999

Additional Information:

FGD scrubbers can be either wet or dry systems. In wet systems, a liquid sorbent is sprayed into the flue gas in an absorber vessel. Limestone and lime-based reagents are most frequently used in scrubbers in the United States (EPA, 1981). Dry and semi-dry FGD systems include spray dryers, and dry injection into a duct or a combustion zone.

References:

EPA, 1981: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Control Techniques for Sulfur Oxide Emissions from Stationary Sources," Second Edition, Research Triangle Park, NC, April 1981.

EPA, 2000: U.S. Environmental Protection Agency, Office of Research and Development, "Coal Utility Environmental Cost (CUECost) Version 3.0" [computer program], February 2000.

Pechan, 1997: E.H. Pechan & Associates, Inc., "Additional Control Measure Evaluation for the Integrated Implementation of the Ozone and Particulate Matter National Ambient Air Quality Standards, and Regional Haze Program," prepared for the U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, July 17, 1997.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Mineral Products Industry

Control Measure Name: Flue Gas Desulfurization

Rule Name: Not Applicable

Pechan Measure Code: S1601

POD: 16

Application: This control is the use of flue gas desulfurization technologies to reduce SO₂ emissions.

This control applies to SO₂ sources from the mineral products industry

Affected SCC:

30500606 Mineral Products, Cement Manufacturing (Dry Process), Kilns
30500612 Mineral Products, Cement Manufacturing (Dry Process), Raw Mat'l Transfer
30500622 Cement Manufacturing (Dry Process), Preheater Kiln
30500706 Mineral Products, Cement Manufacturing (Wet Process), Kilns
30500801 Ceramic Clay/Tile Manufacture, Drying ** (use SCC 3-05-008-13)
30501001 Mineral Products, Coal Mining, Cleaning, & Mat'l Handling (See 305310), Fluidized Bed
30501002 Coal Mining, Cleaning, and Material Handling (See 305310), Flash or Suspension
30501201 Fiberglass Manufacturing, Regenerative Furnace (Wool-type Fiber)
30501202 Fiberglass Manufacturing, Recuperative Furnace (Wool-type Fiber)
30501212 Fiberglass Manufacturing, Recuperative Furnace (Textile-type Fiber)
30501401 Glass Manufacture, Furnace/General**
30501402 Mineral Products, Glass Manufacture, Container Glass: Melting Furnace
30501403 Mineral Products, Glass Manufacture, Flat Glass: Melting Furnace
30501404 Glass Manufacture, Pressed and Blown Glass: Melting Furnace
30501410 Glass Manufacture, Raw Material Handling (All Types of Glass)
30501499 Glass Manufacture, See Comment **
30501604 Mineral Products, Lime Manufacture, Calcining: Rotary Kiln (See 305016-18,-19,-20,-21)
30501905 Mineral Products, Phosphate Rock, Calcining
30599999 Mineral Products, Other Not Defined, Specify in Comments Field

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
							√*			

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 90% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs are based on data for FGD scrubber cost assumptions for utility boilers with a 3 percent coal sulfur content (Pechan, 1997). The assumptions apply to capacities at or above 500 megawatts (MW) [approximately 1,000,000 actual cubic feet per minute (acfm)]. For smaller sizes, the costs are scaled down using the standard 0.6 power law. The costs are based on stack flowrate in cubic feet per minute.

Cost equations for flue gas desulfurization:

AT-A-GLANCE TABLE FOR POINT SOURCES

Capital cost:

DEF = de-escalation factor (to convert to 1990 dollars) = 0.9383

RF = retrofit factor = 1.1

For stack flowrate less than 1,028,000 cu. ft./min =
 $(1,028,000/\text{Flowrate})^{0.6} \times 93.3 \times \text{RF} \times \text{Flowrate} \times \text{DEF}$

For stack flowrate greater than or equal to 1,028,000 cu. ft./min =
 $93.3 \times \text{RF} \times \text{Flowrate} \times \text{DEF}$

Operating and Maintenance (O&M) cost = $3.35 + 0.000729 \times 8736 \times \text{DEF} \times \text{Flowrate}$

Equipment Life in Years = Equiplife = 15 years

Interest Rate = i = 7%

Capital Recovery Factor: $\text{CRF} = [i(1+i)^{\text{Equiplife}}] / [(1+i)^{\text{Equiplife}} - 1]$

Annual cost = (Capital cost * CRF) + O&M cost

O&M Cost Components: The percentages of each O&M cost component were developed using a modified version of EPA's CUE Cost program (EPA, 2000). O&M costs were calculated for a model plant with a flowrate of 800,000 acfm. The percentage of the total O&M cost was then calculated for each O&M cost component. A credit for the sale of by-product was subtracted from the disposal costs. A capacity factor of 65% was assumed. The following assumptions apply to the cost of utilities and disposal:

Calcium Carbonate	15	\$/ton
Dibasic acid	430	\$/ton
Disposal by gypsum stacking	6	\$/ton
Disposal by landfill	30	\$/ton
Credit for by-product	2	\$/ton
Steam	3.5	\$/1000 lb
Electrical energy	25	mills/kWh

The cost effectiveness is determined by dividing the annual cost by the annual tons SO₂ reduced.

Cost Effectiveness: The cost effectiveness is variable depending on stack flow rate in cubic feet per minute.

Comments:

Status: Demonstrated

Last Reviewed: 1999

Additional Information:

FGD scrubbers can be either wet or dry systems. In wet systems, a liquid sorbent is sprayed into the flue gas in an absorber vessel. Limestone and lime-based reagents are most frequently used in scrubbers in the United States (EPA, 1981). Dry and semi-dry FGD systems include spray dryers, and dry injection into a duct or a combustion zone.

AT-A-GLANCE TABLE FOR POINT SOURCES

References:

EPA, 1981: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Control Techniques for Sulfur Oxide Emissions from Stationary Sources," Second Edition, Research Triangle Park, NC, April 1981.

EPA, 2000: U.S. Environmental Protection Agency, Office of Research and Development, "Coal Utility Environmental Cost (CUECost) Version 3.0" [computer program], February 2000.

Pechan, 1997: E.H. Pechan & Associates, Inc., "Additional Control Measure Evaluation for the Integrated Implementation of the Ozone and Particulate Matter National Ambient Air Quality Standards, and Regional Haze Program," prepared for the U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, July 17, 1997.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Petroleum Industry

Control Measure Name: Flue Gas Desulfurization (FGD)

Rule Name: Not Applicable

Pechan Measure Code: S1801

POD: 18

Application: This control is the use of flue gas desulfurization technologies to reduce SO₂ emissions.

This control applies SO₂ sources from the petroleum industry.

Affected SCC:

30600101 Process Heaters, Oil-fired **
30600102 Process Heaters, Gas-fired **
30600103 Petroleum Industry, Process Heaters, Oil-fired
30600104 Petroleum Industry, Process Heaters, Gas-fired
30600105 Process Heaters, Natural Gas-fired
30600106 Process Heaters, Process Gas-fired
30600199 Process Heaters, Other Not Classified
30600201 Petroleum Industry, Catalytic Cracking Units, Fluid Catalytic Cracking Unit
30600202 Catalytic Cracking Units, Catalyst Handling System
30600301 Catalytic Cracking Units, Thermal Catalytic Cracking Unit
30600401 Blowdown Systems, Blowdown System with Vapor Recovery System with Flaring
30600504 Petroleum Industry, Wastewater Treatment, Process Drains and Wastewater Separators
30600805 Petroleum Industry, Fugitive Emissions, Misc.-Sampling/Non-Asphalt Blowing/Purging/etc.
30600903 Flares, Natural Gas
30600904 Flares, Process Gas
30600999 Flares, Not Classified **
30601001 Sludge Converter, General
30601101 Petroleum Industry, Asphalt Blowing, General
30601201 Fluid Coking Units, General
30601401 Petroleum Coke Calcining, Coke Calciner
30609903 Incinerators, Natural Gas
30609904 Incinerators, Process Gas
30699998 Petroleum Products - Not Classified, Not Classified **
30699999 Petroleum Products - Not Classified, Not Classified **

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
							√*			

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 90% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs are based on data for FGD scrubber cost assumptions for utility boilers with a 3 percent coal sulfur content (Pechan, 1997). The assumptions apply to capacities at or above 500 megawatts (MW) [approximately 1,000,000 actual cubic feet per minute (acfm)]. For smaller sizes, the costs are scaled down using the

AT-A-GLANCE TABLE FOR POINT SOURCES

standard 0.6 power law. The costs are based on stack flowrate in cubic feet per minute.

Cost equations for flue gas desulfurization:

Capital cost:

DEF = de-escalation factor (to convert to 1990 dollars) = 0.9383

RF = retrofit factor = 1.1

For stack flowrate less than 1,028,000 cu. ft./min =
 $(1,028,000/\text{Flowrate})^{0.6} \times 93.3 \times \text{RF} \times \text{Flowrate} \times \text{DEF}$

For stack flowrate greater than or equal to 1,028,000 cu. ft./min =
 $93.3 \times \text{RF} \times \text{Flowrate} \times \text{DEF}$

Operating and Maintenance (O&M) cost = $3.35 + 0.000729 \times 8736 \times \text{DEF} \times \text{Flowrate}$

Equipment Life in Years = Equiplife = 15 years

Interest Rate = i = 7%

Capital Recovery Factor: $\text{CRF} = [i(1+i)^{\text{Equiplife}}] / [(1+i)^{\text{Equiplife}} - 1]$

Annual cost = (Capital cost * CRF) + O&M cost

O&M Cost Components: The percentages of each O&M cost component were developed using a modified version of EPA's CUE Cost program (EPA, 2000). O&M costs were calculated for a model plant with a flowrate of 800,000 acfm. The percentage of the total O&M cost was then calculated for each O&M cost component. A credit for the sale of by-product was subtracted from the disposal costs. A capacity factor of 65% was assumed. The following assumptions apply to the cost of utilities and disposal:

Calcium Carbonate	15	\$/ton
Dibasic acid	430	\$/ton
Disposal by gypsum stacking	6	\$/ton
Disposal by landfill	30	\$/ton
Credit for by-product	2	\$/ton
Steam	3.5	\$/1000 lb
Electrical energy	25	mills/kWh

The cost effectiveness is determined by dividing the annual cost by the annual tons SO₂ reduced.

Cost Effectiveness: The cost effectiveness is variable depending on stack flow rate in cubic feet per minute.

Comments:

Status: Demonstrated

Last Reviewed: 1999

AT-A-GLANCE TABLE FOR POINT SOURCES

Additional Information:

FGD scrubbers can be either wet or dry systems. In wet systems, a liquid sorbent is sprayed into the flue gas in an absorber vessel. Limestone and lime-based reagents are most frequently used in scrubbers in the United States (EPA, 1981). Dry and semi-dry FGD systems include spray dryers, and dry injection into a duct or a combustion zone.

References:

EPA, 1981: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Control Techniques for Sulfur Oxide Emissions from Stationary Sources," Second Edition, Research Triangle Park, NC, April 1981.

EPA, 2000: U.S. Environmental Protection Agency, Office of Research and Development, "Coal Utility Environmental Cost (CUECost) Version 3.0" [computer program], February 2000.

Pechan, 1997: E.H. Pechan & Associates, Inc., "Additional Control Measure Evaluation for the Integrated Implementation of the Ozone and Particulate Matter National Ambient Air Quality Standards, and Regional Haze Program," prepared for the U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, July 17, 1997.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Primary Lead Smelters - Sintering

Control Measure Name: Dual Absorption

Rule Name: Not Applicable

Pechan Measure Code: S2801

POD: 28

Application: This control is to increase adsorption efficiency from existing to NSPS level (99.7%) to reduce SO₂ emissions.

This control applies to primary lead smelters with contact absorption.

Affected SCC:

30102306 Sulfuric Acid (Contact Process), Absorber/@99.0% Conversion

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
							√*			

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 99% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Capital and annual costs were developed from model plant data (EPA, 1985). The costs are based on stack flowrate in cubic feet per minute.

Cost equations for dual absorption:

Capital cost = \$990,000 + \$9.836 * Flowrate

Operating cost = \$75,800 + \$12.82 * Flowrate

Equipment Life in Years = Equiplife = 15 years

Interest Rate = I = 7%

Capital Recovery Factor: $CRF = [i(1+i)^{Equiplife}] / [(1+i)^{Equiplife} - 1]$

Annual cost = (Capital cost * CRF) + O&M cost

O&M Cost Components: The O&M cost components for dual absorption are based on two model plants with sulfur intake of 750 tons per day and 1,500 tons per day (EPA, 1985). There are no disposal costs and a credit for the recovered product. Annual operating days are assumed to be 350 days. The following assumptions apply to the cost of utilities and disposal:

Water	0.30	\$/cubic meter
Steam	10.50	\$/gJ
Catalyst	8,437,600	\$/cubic meter
Credit for product	1,120	\$/Mg

AT-A-GLANCE TABLE FOR POINT SOURCES

The cost effectiveness is determined by dividing the annual cost by the annual tons SO₂ reduced.

Cost Effectiveness: The cost effectiveness is variable depending on stack flow rate in cubic feet per minute.

Comments:

Status: Demonstrated

Last Reviewed: 2004

Additional Information:

The contact process is used to produce sulfuric acid from waste gas which contains SO₂. First, the waste gas must be pretreated, which usually involves dust removal, cooling, and scrubbing for further removal of particulate matter and heavy metals, mist, and moisture. After pretreatment, the gas is heated and passed through a catalytic converter (platinum mass units or units containing beds of pelletized vanadium pentoxide) to oxidize the SO₂ to SO₃. The exothermic, reversible oxidation reaction results in a conflict between high equilibrium conversions at lower temperatures and high reaction rates at high temperatures. Because of this, the gas is passed between the catalyst and two or three different heat exchangers in order to achieve conversion of SO₂ to SO₃ of about 92.5 to 98 percent. The gas leaving the final catalyst stage is cooled and introduced to an absorption tower by a stream of strong (98 to 99 percent) acid, where the SO₃ reacts with water in the acid to form additional sulfuric acid. Dilute sulfuric acid or water is added to the recirculating acid to maintain the desired concentration (EPA, 1981; EPA, 1997).

The double-contact, or double-absorption, process for making sulfuric acid from waste gas containing SO₂ is essentially the same as the single-contact process with the addition of an interpass absorption tower. The waste gas is cleaned and dried as in the single-contact process before entering the process. Upon leaving the second or third catalyst bed, depending upon the process, the gas is cooled and introduced to a packed-bed, counter-current absorption tower where it contacts 98 to 99 percent sulfuric acid. After the absorbing tower, the gas is reheated and passed to the third or fourth catalyst bed, where approximately 97 percent of the remaining SO₂ is converted to SO₃ and passed to the final absorption tower for conversion to sulfuric acid as in the single-contact process. No cost data were available for either single- or double-contact sulfuric acid plants controls (EPA, 1981; EPA, 1997).

References:

EPA, 1981: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Control Techniques for Sulfur Oxide Emissions from Stationary Sources," Second Edition, Research Triangle Park, NC, April 1981.

EPA, 1997: U.S. Environmental Protection Agency, "Compilation of Air Pollutant Emission Factors, Volume I, Stationary Point and Area Sources," AP-42, Fifth Edition, Research Triangle Park, NC, October 1997.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Primary Metals Industry

Control Measure Name: Flue Gas Desulfurization

Rule Name: Not Applicable

Pechan Measure Code: S1401

POD: 14

Application: This control is the use of flue gas desulfurization technologies to reduce NOx emissions.

This control applies to SO2 sources in the primary metals industry.

Affected SCC:

30300101 Primary Metal Production, Aluminum Ore (Electro-reduction), Prebaked Reduction Cell
30300102 Aluminum Ore (Electro-reduction), Horizontal Stud Soderberg Cell
30300103 Aluminum Ore (Electro-reduction), Vertical Stud Soderberg Cell
30300105 Primary Metal Production, Aluminum Ore (Electro-reduction), Anode Baking Furnace
30300199 Aluminum Ore (Electro-reduction), Not Classified **
30300813 Iron Production (See 3-03-015), Windbox
30300817 Iron Production (See 3-03-015), Cooler
30300824 Iron Production (See 3-03-015), Blast Heating Stoves
30300825 Primary Metal Production, Iron Production (See 3-03-015), Cast House
30300908 Primary Metal Prod., Steel (See 303015), Electric Arc Furnace-Carbon Steel (Stack)
30300911 Steel Manufacturing (See 3-03-015), Soaking Pits
30300933 Primary Metal Production, Steel Manufacturing (See 3-03-015), Reheat Furnaces
30300999 Primary Metal Production, Steel Manufacturing (See 3-03-015), Other Not Classified
30301001 Lead Production, Sintering: Single Stream
30301002 Lead Production, Blast Furnace Operation
30301199 Molybdenum, Other Not Classified
30399999 Other Not Classified, Other Not Classified

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
							√*			

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 90% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs are based on stack flowrate in cubic feet per minute. The equations below are simplified from the EPA Control Cost Manual (EPA, 2002).

Cost equations for flue gas desulfurization:

Capital cost:

DEF = de-escalation factor (to convert to 1990 dollars) = 0.9383

RF = retrofit factor = 1.1

For stack flowrate less than 1,0280,000 cu. ft./min =

AT-A-GLANCE TABLE FOR POINT SOURCES

$$(1,0280,000/\text{Flowrate})^{0.6} * 93.3 * \text{RF} * \text{Flowrate} * \text{DEF}$$

For stack flowrate greater than or equal to 1,0280,000 cu. ft./min =
 $93.3 * \text{RF} * \text{Flowrate} * \text{DEF}$

Operating and Maintenance (O&M) cost = $3.35 + 0.000729 * 8736 * \text{DEF} * \text{Flowrate}$

Equipment Life in Years = Equiplife = 15 years

Interest Rate = i = 7%

Capital Recovery Factor: $\text{CRF} = [i (1 + i)^{\text{Equiplife}}] / [(1 + i)^{\text{Equiplife}} - 1]$

Annual cost = (Capital cost * CRF) + O&M cost

The cost effectiveness is determined by dividing the annual cost by the annual tons SO₂ reduced.

Cost Effectiveness: The cost effectiveness is variable depending on stack flow rate in cubic feet per minute.

Comments:

Status: Demonstrated

Last Reviewed: 1999

Additional Information:

FGD scrubbers can be either wet or dry systems. In wet systems, a liquid sorbent is sprayed into the flue gas in an absorber vessel. Limestone and lime-based reagents are most frequently used in scrubbers in the United States (EPA, 2002). Dry and semi-dry FGD systems include spray dryers, and dry injection into a duct or a combustion zone.

References:

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Primary Zinc Smelters - Sintering

Control Measure Name: Dual Absorption

Rule Name: Not Applicable

Pechan Measure Code: S2901

POD: 29

Application: This control is to increase adsorption efficiency from existing to NSPS level (99.7%) to reduce SO₂ emissions.

This control applies to primary lead smelters with contact absorption.

Affected SCC:

30102306 Sulfuric Acid (Contact Process), Absorber/@99.0% Conversion

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
							√*			

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 99% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Capital and annual costs were developed from model plant data (EPA, 1985). The costs are based on stack flowrate in cubic feet per minute.

Cost equations for dual absorption:

Capital cost = \$990,000 + \$9.836 * Flowrate

Operating cost = \$75,800 + \$12.82 * Flowrate

Equipment Life in Years = Equiplife = 15 years

Interest Rate = I = 7%

Capital Recovery Factor: $CRF = [i(1+i)^{Equiplife}] / [(1+i)^{Equiplife} - 1]$

Annual cost = (Capital cost * CRF) + O&M cost

O&M Cost Components: The O&M cost components for dual absorption are based on two model plants with sulfur intake of 750 tons per day and 1,500 tons per day (EPA, 1985). There are no disposal costs and a credit for the recovered product. Annual operating days are assumed to be 350 days. The following assumptions apply to the cost of utilities and disposal:

Water	0.30	\$/cubic meter
Steam	10.50	\$/gJ
Catalyst	8,437,600	\$/cubic meter
Credit for product	1,120	\$/Mg

AT-A-GLANCE TABLE FOR POINT SOURCES

The cost effectiveness is determined by dividing the annual cost by the annual tons SO₂ reduced.

Cost Effectiveness: The cost effectiveness is variable depending on stack flow rate in cubic feet per minute.

Comments:

Status: Demonstrated

Last Reviewed: 2004

Additional Information:

The contact process is used to produce sulfuric acid from waste gas which contains SO₂. First, the waste gas must be pretreated, which usually involves dust removal, cooling, and scrubbing for further removal of particulate matter and heavy metals, mist, and moisture. After pretreatment, the gas is heated and passed through a catalytic converter (platinum mass units or units containing beds of pelletized vanadium pentoxide) to oxidize the SO₂ to SO₃. The exothermic, reversible oxidation reaction results in a conflict between high equilibrium conversions at lower temperatures and high reaction rates at high temperatures. Because of this, the gas is passed between the catalyst and two or three different heat exchangers in order to achieve conversion of SO₂ to SO₃ of about 92.5 to 98 percent. The gas leaving the final catalyst stage is cooled and introduced to an absorption tower by a stream of strong (98 to 99 percent) acid, where the SO₃ reacts with water in the acid to form additional sulfuric acid. Dilute sulfuric acid or water is added to the recirculating acid to maintain the desired concentration (EPA, 1981; EPA, 1997).

The double-contact, or double-absorption, process for making sulfuric acid from waste gas containing SO₂ is essentially the same as the single-contact process with the addition of an interpass absorption tower. The waste gas is cleaned and dried as in the single-contact process before entering the process. Upon leaving the second or third catalyst bed, depending upon the process, the gas is cooled and introduced to a packed-bed, counter-current absorption tower where it contacts 98 to 99 percent sulfuric acid. After the absorbing tower, the gas is reheated and passed to the third or fourth catalyst bed, where approximately 97 percent of the remaining SO₂ is converted to SO₃ and passed to the final absorption tower for conversion to sulfuric acid as in the single-contact process. No cost data were available for either single- or double-contact sulfuric acid plants controls (EPA, 1981; EPA, 1997).

References:

EPA, 1981: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Control Techniques for Sulfur Oxide Emissions from Stationary Sources," Second Edition, Research Triangle Park, NC, April 1981.

EPA, 1997: U.S. Environmental Protection Agency, "Compilation of Air Pollutant Emission Factors, Volume I, Stationary Point and Area Sources," AP-42, Fifth Edition, Research Triangle Park, NC, October 1997.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Process Heaters (Oil and Gas Production)

Control Measure Name: Flue Gas Desulfurization

Rule Name: Not Applicable

Pechan Measure Code: S1301

POD: 13

Application: This control is the use of flue gas desulfurization technologies to reduce SO₂ emissions.

This control applies to processes heaters involved in oil and gas production.
Emissions from these sources are classified under SCCs beginning with 310004.

Affected SCC:

31000402 Process Heaters, Residual Oil
31000403 Process Heaters, Crude Oil
31000404 Oil and Gas Production, Process Heaters, Natural Gas
31000405 Process Heaters, Process Gas

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
							√*			

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 90% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs are based on data for FGD scrubber cost assumptions for utility boilers with a 3 percent coal sulfur content (Pechan, 1997). The assumptions apply to capacities at or above 500 megawatts (MW) [approximately 1,000,000 actual cubic feet per minute (acfm)]. For smaller sizes, the costs are scaled down using the standard 0.6 power law. The costs are based on stack flowrate in cubic feet per minute.

Cost equations for flue gas desulfurization:

Capital cost:

DEF = de-escalation factor (to convert to 1990 dollars) = 0.9383

RF = retrofit factor = 1.1

For stack flowrate less than 1,0280,000 cu. ft./min =
 $(1,0280,000/\text{Flowrate})^{0.6} \times 93.3 \times \text{RF} \times \text{Flowrate} \times \text{DEF}$

For stack flowrate greater than or equal to 1,0280,000 cu. ft./min =
 $93.3 \times \text{RF} \times \text{Flowrate} \times \text{DEF}$

Operating and Maintenance (O&M) cost = $3.35 + 0.000729 \times 8736 \times \text{DEF} \times \text{Flowrate}$

Equipment Life in Years = Equiplife = 15 years

AT-A-GLANCE TABLE FOR POINT SOURCES

Interest Rate = $i = 7\%$

Capital Recovery Factor: $CRF = [i(1+i)^{\text{Equiplife}}] / [(1+i)^{\text{Equiplife}} - 1]$

Annual cost = (Capital cost * CRF) + O&M cost

O&M Cost Components: The percentages of each O&M cost component were developed using a modified version of EPA's CUE Cost program (EPA, 2000). O&M costs were calculated for a model plant with a flowrate of 800,000 acfm. The percentage of the total O&M cost was then calculated for each O&M cost component. A credit for the sale of by-product was subtracted from the disposal costs. A capacity factor of 65% was assumed. The following assumptions apply to the cost of utilities and disposal:

Calcium Carbonate	15	\$/ton
Dibasic acid	430	\$/ton
Disposal by gypsum stacking	6	\$/ton
Disposal by landfill	30	\$/ton
Credit for by-product	2	\$/ton
Steam	3.5	\$/1000 lb
Electrical energy	25	mills/kWh

The cost effectiveness is determined by dividing the annual cost by the annual tons SO₂ reduced.

Cost Effectiveness: The cost effectiveness is variable depending on stack flow rate in cubic feet per minute.

Comments:

Status: Demonstrated

Last Reviewed: 1999

Additional Information:

FGD scrubbers can be either wet or dry systems. In wet systems, a liquid sorbent is sprayed into the flue gas in an absorber vessel. Limestone and lime-based reagents are most frequently used in scrubbers in the United States (EPA, 1981). Dry and semi-dry FGD systems include spray dryers, and dry injection into a duct or a combustion zone.

References:

EPA, 1981: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Control Techniques for Sulfur Oxide Emissions from Stationary Sources," Second Edition, Research Triangle Park, NC, April 1981.

EPA, 2000: U.S. Environmental Protection Agency, Office of Research and Development, "Coal Utility Environmental Cost (CUECost) Version 3.0" [computer program], February 2000.

Pechan, 1997: E.H. Pechan & Associates, Inc., "Additional Control Measure Evaluation for the Integrated Implementation of the Ozone and Particulate Matter National Ambient Air Quality Standards, and Regional Haze Program," prepared for the U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, July 17, 1997.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Pulp and Paper Industry (Sulfate Pulping)

Control Measure Name: Flue Gas Desulfurization

Rule Name: Not Applicable

Pechan Measure Code: S1701

POD: 17

Application: This control is the use of flue gas desulfurization technologies to reduce NOx emissions.

This control applies to sulfate pulping processes involved in the pulp and paper industry. Emissions from these sources are classified under SCCs beginning with 307001.

Affected SCC:

30700104 Pulp, Paper & Wood, Sulfate Pulping, Recovery Furnace/Direct Contact Evaporator

30700106 Pulp and Paper and Wood Products, Sulfate (Kraft) Pulping, Lime Kiln

30700110 Sulfate (Kraft) Pulping, Recovery Furnace/Indirect Contact Evaporator

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
							√*			

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 90% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs are based on stack flowrate in cubic feet per minute. The equations below are simplified from the EPA Control Cost Manual (EPA, 2002).

Cost equations for flue gas desulfurization:

Capital cost:

DEF = de-escalation factor (to convert to 1990 dollars) = 0.9383

RF = retrofit factor = 1.1

For stack flowrate less than 1,0280,000 cu. ft./min =
 $(1,0280,000/\text{Flowrate})^{0.6} \times 93.3 \times \text{RF} \times \text{Flowrate} \times \text{DEF}$

For stack flowrate greater than or equal to 1,0280,000 cu. ft./min =
 $93.3 \times \text{RF} \times \text{Flowrate} \times \text{DEF}$

Operating and Maintenance (O&M) cost = $3.35 + 0.000729 \times 8736 \times \text{DEF} \times \text{Flowrate}$

Equipment Life in Years = Equiplife = 15 years

Interest Rate = I = 7%

Capital Recovery Factor: $\text{CRF} = [i(1+i)^{\text{Equiplife}}] / [(1+i)^{\text{Equiplife}} - 1]$

Annual cost = (Capital cost * CRF) + O&M cost

AT-A-GLANCE TABLE FOR POINT SOURCES

The cost effectiveness is determined by dividing the annual cost by the annual tons SO₂ reduced.

Cost Effectiveness: The cost effectiveness is variable depending on stack flow rate in cubic feet per minute.

Comments:

Status: Demonstrated

Last Reviewed: 1999

Additional Information:

FGD scrubbers can be either wet or dry systems. In wet systems, a liquid sorbent is sprayed into the flue gas in an absorber vessel. Limestone and lime-based reagents are most frequently used in scrubbers in the United States (EPA, 2002). Dry and semi-dry FGD systems include spray dryers, and dry injection into a duct or a combustion zone.

References:

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Residual Oil (Commercial/Institutional Boilers)

Control Measure Name: Flue Gas Desulfurization

Rule Name: Not Applicable

Pechan Measure Code: S2401

POD: 24

Application: This control is the use of flue gas desulfurization technologies to reduce SO₂ emissions.

This control applies to residual oil-fired commercial and institutional boilers. Emissions from these sources are classified under SCCs beginning with 103004.

Affected SCC:

10300401 Commercial/Institutional, Residual Oil, Grade 6 Oil

10300402 Commercial/Institutional, Residual Oil, 10-100 Million Btu/hr **

10300404 Commercial/Institutional, Residual Oil, Grade 5 Oil

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
							√*			

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 90% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs are based on data for FGD scrubber cost assumptions for utility boilers with a 3 percent coal sulfur content (Pechan, 1997). The assumptions apply to capacities at or above 500 megawatts (MW) [approximately 1,000,000 actual cubic feet per minute (acfm)]. For smaller sizes, the costs are scaled down using the standard 0.6 power law. The costs are based on stack flowrate in cubic feet per minute.

Cost equations for flue gas desulfurization:

Capital cost:

DEF = de-escalation factor (to convert to 1990 dollars) = 0.9383

RF = retrofit factor = 1.1

For stack flowrate less than 1,028,000 cu. ft./min =
 $(1,028,000/\text{Flowrate})^{0.6} \times 93.3 \times \text{RF} \times \text{Flowrate} \times \text{DEF}$

For stack flowrate greater than or equal to 1,028,000 cu. ft./min =
 $93.3 \times \text{RF} \times \text{Flowrate} \times \text{DEF}$

Operating and Maintenance (O&M) cost = $3.35 + 0.000729 \times 8736 \times \text{DEF} \times \text{Flowrate}$

Equipment Life in Years = Equiplife = 15 years

Interest Rate = I = 7%

AT-A-GLANCE TABLE FOR POINT SOURCES

Capital Recovery Factor: $CRF = [i(1+i)^{\text{Equiplife}}] / [(1+i)^{\text{Equiplife}} - 1]$

Annual cost = (Capital cost * CRF) + O&M cost

O&M Cost Components: The percentages of each O&M cost component were developed using a modified version of EPA's CUE Cost program (EPA, 2000). O&M costs were calculated for a model plant with a flowrate of 800,000 acfm. The percentage of the total O&M cost was then calculated for each O&M cost component. A credit for the sale of by-product was subtracted from the disposal costs. A capacity factor of 65% was assumed. The following assumptions apply to the cost of utilities and disposal:

Calcium Carbonate	15	\$/ton
Dibasic acid	430	\$/ton
Disposal by gypsum stacking	6	\$/ton
Disposal by landfill	30	\$/ton
Credit for by-product	2	\$/ton
Steam	3.5	\$/1000 lb
Electrical energy	25	mills/kWh

The cost effectiveness is determined by dividing the annual cost by the annual tons SO₂ reduced.

Cost Effectiveness: The cost effectiveness is variable depending on stack flow rate in cubic feet per minute.

Comments:

Status: Demonstrated	Last Reviewed: 1999
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Additional Information:

FGD scrubbers can be either wet or dry systems. In wet systems, a liquid sorbent is sprayed into the flue gas in an absorber vessel. Limestone and lime-based reagents are most frequently used in scrubbers in the United States (EPA, 1981). Dry and semi-dry FGD systems include spray dryers, and dry injection into a duct or a combustion zone.

References:

EPA, 1981: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Control Techniques for Sulfur Oxide Emissions from Stationary Sources," Second Edition, Research Triangle Park, NC, April 1981.

EPA, 2000: U.S. Environmental Protection Agency, Office of Research and Development, "Coal Utility Environmental Cost (CUECost) Version 3.0" [computer program], February 2000.

Pechan, 1997: E.H. Pechan & Associates, Inc., "Additional Control Measure Evaluation for the Integrated Implementation of the Ozone and Particulate Matter National Ambient Air Quality Standards, and Regional Haze Program," prepared for the U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, July 17, 1997.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Residual Oil (Commercial/Institutional Boilers)

Control Measure Name: Wet Flue Gas Desulfurization

Rule Name: Not Applicable

Pechan Measure Code: S3006

POD: 20

Application: Two types of dry sorbents were injected into the ductwork downstream of the boiler to reduce SO₂ emissions. Either calcium-based sorbent was injected upstream of the economizer, or sodium-based sorbent downstream of the air heater. Humidification downstream of the dry sorbent injection was incorporated to aid SO₂ capture and lower flue gas temperature and gas flow before entering the fabric filter dust collector (FFDC).

Affected SCC:

10200401 Industrial, Residual Oil, Grade 6 Oil
10200402 Residual Oil, 10-100 Million Btu/hr **
10200404 Industrial, Residual Oil, Grade 5 Oil
10200405 Residual Oil, Cogeneration

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
							√*			

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 90% from uncontrolled

Equipment Life: 30 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: In general, an EPRI methodology was used for the cost estimates, with the following cost factor is used for the non-process costs:

General Facilities: 5% of total direct process cost
Engineering and home office fees: 10% of total direct process cost
Process contingency: 5% of total direct process cost
Project contingency: 15% of total direct process and the above three non-process costs
Retrofit Factor: 30%
Preproduction cost: 2% of total plant investment with retrofit costs
Inventory Capital: cost for a 30-day reagent storage

The levelized costs (\$/ton of SO₂ removed) were calculated using the estimates of the capital costs and increased consumable rates associated with each technology. The costs are based on 1999 dollars. The economic factors used in these calculation were as follows:

Lime: \$ 50 / ton
Limestone: \$15 /ton
Water: \$0.0006 / gal
Solid Waste Disposal: \$12 / ton
Operator Cost: \$ 30 /hr

AT-A-GLANCE TABLE FOR POINT SOURCES

Useful life: 30 years
Carrying charges: 12%
Levelization factor: 1
Maintenance cost (% of capital cost): 3.0 for FGD

Cost Effectiveness: Cost effectiveness is the function of boiler capacity. Following cost per ton (1999\$) is used depending on the boiler capacity.

For Boilers ,
< 100 MMBtu/hr - \$4,524 per ton SO₂ reduced
> 100 MMBtu/hr and < 250 MMBtu/hr - \$3,489 per ton SO₂ reduced
> 250 MMBtu/hr - \$2,295 / ton of SO₂ reduced

Comments:

Status:	Last Reviewed: 2005
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Additional Information:

References:

EPA, 2003: U.S. Environmental Protection Agency: "Methodology, Assumptions, and References Preliminary SO₂ Controls Cost Estimates For Industrial Boilers", October 2003.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Residual Oil (Industrial Boilers)

Control Measure Name: Flue Gas Desulfurization

Rule Name: Not Applicable

Pechan Measure Code: S2001

POD: 20

Application: This control is the use of flue gas desulfurization technologies to reduce SO₂ emissions.

This control applies to industrial residual-oil-fired boilers. Emissions from these sources are classified under SCCs beginning with 102004.

Affected SCC:

10200401 Industrial, Residual Oil, Grade 6 Oil
10200402 Residual Oil, 10-100 Million Btu/hr **
10200404 Industrial, Residual Oil, Grade 5 Oil
10200405 Residual Oil, Cogeneration

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
							√*			

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 90% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs are based on data for FGD scrubber cost assumptions for utility boilers with a 3 percent coal sulfur content (Pechan, 1997). The assumptions apply to capacities at or above 500 megawatts (MW) [approximately 1,000,000 actual cubic feet per minute (acfm)]. For smaller sizes, the costs are scaled down using the standard 0.6 power law. The costs are based on stack flowrate in cubic feet per minute.

Cost equations for flue gas desulfurization:

Capital cost:

DEF = de-escalation factor (to convert to 1990 dollars) = 0.9383

RF = retrofit factor = 1.1

For stack flowrate less than 1,0280,000 cu. ft./min =
 $(1,0280,000/\text{Flowrate})^{0.6} * 93.3 * \text{RF} * \text{Flowrate} * \text{DEF}$

For stack flowrate greater than or equal to 1,0280,000 cu. ft./min =
 $93.3 * \text{RF} * \text{Flowrate} * \text{DEF}$

Operating and Maintenance (O&M) cost = $3.35 + 0.000729 * 8736 * \text{DEF} * \text{Flowrate}$

Equipment Life in Years = Equiplife = 15 years

AT-A-GLANCE TABLE FOR POINT SOURCES

Interest Rate = $i = 7\%$

Capital Recovery Factor: $CRF = [i(1+i)^{\text{Equiplife}}] / [(1+i)^{\text{Equiplife}} - 1]$

Annual cost = (Capital cost * CRF) + O&M cost

O&M Cost Components: The percentages of each O&M cost component were developed using a modified version of EPA's CUE Cost program (EPA, 2000). O&M costs were calculated for a model plant with a flowrate of 800,000 acfm. The percentage of the total O&M cost was then calculated for each O&M cost component. A credit for the sale of by-product was subtracted from the disposal costs. A capacity factor of 65% was assumed. The following assumptions apply to the cost of utilities and disposal:

Calcium Carbonate	15	\$/ton
Dibasic acid	430	\$/ton
Disposal by gypsum stacking	6	\$/ton
Disposal by landfill	30	\$/ton
Credit for by-product	2	\$/ton
Steam	3.5	\$/1000 lb
Electrical energy	25	mills/kWh

The cost effectiveness is determined by dividing the annual cost by the annual tons SO₂ reduced.

Cost Effectiveness: The cost effectiveness is variable depending on stack flow rate in cubic feet per minute.

Comments:

Status: Demonstrated

Last Reviewed: 1999

Additional Information:

FGD scrubbers can be either wet or dry systems. In wet systems, a liquid sorbent is sprayed into the flue gas in an absorber vessel. Limestone and lime-based reagents are most frequently used in scrubbers in the United States (EPA, 1981). Dry and semi-dry FGD systems include spray dryers, and dry injection into a duct or a combustion zone.

References:

EPA, 1981: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Control Techniques for Sulfur Oxide Emissions from Stationary Sources," Second Edition, Research Triangle Park, NC, April 1981.

EPA, 2000: U.S. Environmental Protection Agency, Office of Research and Development, "Coal Utility Environmental Cost (CUECost) Version 3.0" [computer program], February 2000.

Pechan, 1997: E.H. Pechan & Associates, Inc., "Additional Control Measure Evaluation for the Integrated Implementation of the Ozone and Particulate Matter National Ambient Air Quality Standards, and Regional Haze Program," prepared for the U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, July 17, 1997.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Secondary Metal Production

Control Measure Name: Flue Gas Desulfurization

Rule Name: Not Applicable

Pechan Measure Code: S1501

POD: 15

Application: This control is the use of flue gas desulfurization technologies to reduce SO₂ emissions.

This control applies secondary metal production classified under SCC 30499999.

Affected SCC:

30499999 Secondary Metal Production, Other Not Classified, Specify in Comments Field

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
							√*			

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 90% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs are based on data for FGD scrubber cost assumptions for utility boilers with a 3 percent coal sulfur content (Pechan, 1997). The assumptions apply to capacities at or above 500 megawatts (MW) [approximately 1,000,000 actual cubic feet per minute (acfm)]. For smaller sizes, the costs are scaled down using the standard 0.6 power law. The costs are based on stack flowrate in cubic feet per minute.

Cost equations for flue gas desulfurization:

Capital cost:

DEF = de-escalation factor (to convert to 1990 dollars) = 0.9383

RF = retrofit factor = 1.1

For stack flowrate less than 1,028,000 cu. ft./min =
 $(1,028,000/\text{Flowrate})^{0.6} * 93.3 * \text{RF} * \text{Flowrate} * \text{DEF}$

For stack flowrate greater than or equal to 1,028,000 cu. ft./min =
 $93.3 * \text{RF} * \text{Flowrate} * \text{DEF}$

Operating and Maintenance (O&M) cost = $3.35 + 0.000729 * 8736 * \text{DEF} * \text{Flowrate}$

Equipment Life in Years = Equiplife = 15 years

Interest Rate = I = 7%

Capital Recovery Factor: $\text{CRF} = [i(1+i)^{\text{Equiplife}}] / [(1+i)^{\text{Equiplife}} - 1]$

AT-A-GLANCE TABLE FOR POINT SOURCES

Annual cost = (Capital cost * CRF) + O&M cost

O&M Cost Components: The percentages of each O&M cost component were developed using a modified version of EPA's CUE Cost program (EPA, 2000). O&M costs were calculated for a model plant with a flowrate of 800,000 acfm. The percentage of the total O&M cost was then calculated for each O&M cost component. A credit for the sale of by-product was subtracted from the disposal costs. A capacity factor of 65% was assumed. The following assumptions apply to the cost of utilities and disposal:

Calcium Carbonate	15	\$/ton
Dibasic acid	430	\$/ton
Disposal by gypsum stacking	6	\$/ton
Disposal by landfill	30	\$/ton
Credit for by-product	2	\$/ton□
Steam	3.5	\$/1000 lb
Electrical energy	25	mills/kWh

The cost effectiveness is determined by dividing the annual cost by the annual tons SO₂ reduced.

Cost Effectiveness: The cost effectiveness is variable depending on stack flow rate in cubic feet per minute.

Comments:

Status: Demonstrated

Last Reviewed: 1999

Additional Information:

FGD scrubbers can be either wet or dry systems. In wet systems, a liquid sorbent is sprayed into the flue gas in an absorber vessel. Limestone and lime-based reagents are most frequently used in scrubbers in the United States (EPA, 1981). Dry and semi-dry FGD systems include spray dryers, and dry injection into a duct or a combustion zone.

References:

EPA, 1981: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Control Techniques for Sulfur Oxide Emissions from Stationary Sources," Second Edition, Research Triangle Park, NC, April 1981.

EPA, 2000: U.S. Environmental Protection Agency, Office of Research and Development, "Coal Utility Environmental Cost (CUECost) Version 3.0" [computer program], February 2000.

Pechan, 1997: E.H. Pechan & Associates, Inc., "Additional Control Measure Evaluation for the Integrated Implementation of the Ozone and Particulate Matter National Ambient Air Quality Standards, and Regional Haze Program," prepared for the U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, July 17, 1997.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Steam Generating Unit-Coal/Oil

Control Measure Name: Flue Gas Desulfurization

Rule Name: Not Applicable

Pechan Measure Code: S2601

POD: 26

Application: This control is the use of flue gas desulfurization technologies to reduce NOx emissions.

This control applies to coal and oil- fired steam generating units.

Affected SCC:

10200104 Anthracite Coal, Traveling Grate (Overfeed) Stoker
10200501 Industrial, Distillate Oil, Grades 1 and 2 Oil
10200502 Distillate Oil, 10-100 Million Btu/hr **
10200504 Industrial, Distillate Oil, Grade 4 Oil
10200505 Industrial, Distillate Oil, Cogeneration
10201101 Bagasse, All Boiler Sizes
10201404 CO Boiler, Residual Oil
10300102 Anthracite Coal, Traveling Grate (Overfeed) Stoker
10300309 Lignite, Spreader Stoker
10300501 Commercial/Institutional, Distillate Oil, Grades 1 and 2 Oil
10300502 Commercial/Institutional, Distillate Oil, 10-100 Million Btu/hr **
10300504 Commercial/Institutional, Distillate Oil, Grade 4 Oil

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
							√*			

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 90% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs are based on data for FGD scrubber cost assumptions for utility boilers with a 3 percent coal sulfur content (Pechan, 1997). The assumptions apply to capacities at or above 500 megawatts (MW) [approximately 1,000,000 actual cubic feet per minute (acfm)]. For smaller sizes, the costs are scaled down using the standard 0.6 power law. The costs are based on stack flowrate in cubic feet per minute.

Cost equations for flue gas desulfurization:

Capital cost:

DEF = de-escalation factor (to convert to 1990 dollars) = 0.9383

RF = retrofit factor = 1.1

For stack flowrate less than 1,0280,000 cu. ft./min =
 $(1,0280,000/\text{Flowrate})^{0.6} \times 93.3 \times \text{RF} \times \text{Flowrate} \times \text{DEF}$

AT-A-GLANCE TABLE FOR POINT SOURCES

For stack flowrate greater than or equal to 1,0280,000 cu. ft./min =
 $93.3 * RF * \text{Flowrate} * DEF$

Operating and Maintenance (O&M) cost = $3.35 + 0.000729 * 8736 * DEF * \text{Flowrate}$

Equipment Life in Years = Equiplife = 15 years

Interest Rate = $i = 7\%$

Capital Recovery Factor: $CRF = [i(1+i)^{\text{Equiplife}}] / [(1+i)^{\text{Equiplife}} - 1]$

Annual cost = (Capital cost * CRF) + O&M cost

O&M Cost Components: The percentages of each O&M cost component were developed using a modified version of EPA's CUE Cost program (EPA, 2000). O&M costs were calculated for a model plant with a flowrate of 800,000 acfm. The percentage of the total O&M cost was then calculated for each O&M cost component. A credit for the sale of by-product was subtracted from the disposal costs. A capacity factor of 65% was assumed. The following assumptions apply to the cost of utilities and disposal:

Calcium Carbonate	15	\$/ton
Dibasic acid	430	\$/ton
Disposal by gypsum stacking	6	\$/ton
Disposal by landfill	30	\$/ton
Credit for by-product	2	\$/ton
Steam	3.5	\$/1000 lb
Electrical energy	25	mills/kWh

The cost effectiveness is determined by dividing the annual cost by the annual tons SO₂ reduced.

Cost Effectiveness: The cost effectiveness is variable depending on stack flow rate in cubic feet per minute.

Comments:

Status: Demonstrated

Last Reviewed: 1999

Additional Information:

FGD scrubbers can be either wet or dry systems. In wet systems, a liquid sorbent is sprayed into the flue gas in an absorber vessel. Limestone and lime-based reagents are most frequently used in scrubbers in the United States (EPA, 1981). Dry and semi-dry FGD systems include spray dryers, and dry injection into a duct or a combustion zone.

References:

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Sulfur Recovery Plants - Elemental Sulfur

Control Measure Name: Amine Scrubbing

Rule Name: Not Applicable

Pechan Measure Code: S0601

POD: 06

Application: This control is the use of amine scrubbing add-on controls to reduce SO₂ emissions.

This control applies to stage 2 elemental sulfur recovery plants with out control, 92-95% removal.

Affected SCC:

30103201 Elemental Sulfur Production, Mod. Claus: 2 Stage w/o Control (92-95% Removal)

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
							√*			

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 98% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Capital and annual costs were developed from model plant data (EPA, 1986). The costs are based on stack flowrate in cubic feet per minute.

Cost equations for amine scrubbing:

Capital cost = \$2,882,540 + \$244.74 * Flow rate

Operating and Maintenance (O&M) cost = \$749,170 + \$148.40 * Flow rate

Equipment Life in Years = Equiplife = 15 years

Interest Rate = I = 7%

Capital Recovery Factor: $CRF = [i(1+i)^{Equiplife}] / [(1+i)^{Equiplife} - 1]$

Annual cost = (Capital cost * CRF) + O&M cost

O&M Cost Components: The O&M cost components for amine scrubbing of Claus system tail gas are based on three model plants as given below (EPA, 1983):

Sulfur Intake	Catalytic Recovery	Claus Recovery
10 tons per day	two-stage	95.1%
50 tons per day	three-stage	96.4%
100 tons per day	three-stage	96.4%

There are no disposal costs and a credit for the recovered product. Annual operating days are assumed to be 350 days. The following assumptions apply to the cost of utilities and disposal:

AT-A-GLANCE TABLE FOR POINT SOURCES

Catalyst		
a. alumina	17	\$/cubic feet
b. cobalt-molybdenum	170	\$/cubic feet
Reagent		
a. Diisopropanolamine	1.07	\$/lb
b. Soda	300	\$/ton
Steam	6.00	\$/1000 lb
Steam Condensate	1.25	\$/1000 lb
Water		
a. Boiler	0.05	\$/1000 gal
b. Cooling	1.50	\$/1000 lb
Natural Gas	3.50	\$/MMBtu
Electrical energy	0.05	\$/kWh
Credit for byproduct recovery	1.88	\$/ton

The cost effectiveness is determined by dividing the annual cost by the annual tons SO₂ reduced.

Cost Effectiveness: The cost effectiveness is variable depending on stack flow rate in cubic feet per minute.

Comments:

Status: Demonstrated

Last Reviewed: 1999

Additional Information:

Refinery sour gas streams are generally fed to a regenerative type of H₂S removal process. The concentrated acid gas is then sent to the sulfur recovery unit. The Claus process is the most widely used method of producing sulfur from refinery H₂S (Pechan, 1999). The modified Claus process is based on producing elemental sulfur by first converting one-third of the H₂S feed by precise combustion with air. The combustion products are then allowed to react thermally with the remaining two-thirds of the H₂S feed in the presence of a suitable catalyst to form sulfur vapor.

References:

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1999: E.H. Pechan & Associates, Inc., "Control Measure Evaluations: The Control Measure Data Base For the National Emission Trends Inventory (AirControlNET) – Draft Report," prepared for the U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, September 1999.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Sulfur Recovery Plants - Elemental Sulfur

Control Measure Name: Amine Scrubbing + Flue Gas Desulfurization

Rule Name: Not Applicable

Pechan Measure Code: S0602

POD: 06

Application: This control is the use of amine scrubbing add-on controls combined with flue gas desulfurization technologies to reduce SO₂ emissions.

This control applies to stage 4 elemental sulfur recovery plants with out control, 96-97% removal.

Affected SCC:

30103201 Elemental Sulfur Production, Mod. Claus: 2 Stage w/o Control (92-95% Removal)

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
							√*			

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 99.8% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs are based on stack flowrate in cubic feet per minute. The equations below are simplified from the EPA Control Cost Manual (EPA, 2002).

Cost equations for amine scrubbing and FGD:

Capital cost:

DEF = de-escalation factor (to convert to 1990 dollars) = 0.9383

RF = retrofit factor = 1.1

For stack flowrate less than 1,0280,000 cu. ft./min = 2,882,540 + (244.74 * Flowrate) + ((1,0280,000/Flowrate)^{0.6}) * 93.3*RF*Flowrate*DEF

For stack flowrate greater than or equal to 1,0280,000 cu. ft./min = 2,882,540 + (244.74 * Flowrate) + (93.3*RF*Flowrate*DEF)

Operating and Maintenance (O&M) cost = 749,170 + 148.40 * Flowrate + 3.35+0.000729*8736*DEF * Flowrate

Equipment Life in Years = Equiplife = 15 years

Interest Rate = I = 7%

Capital Recovery Factor: $CRF = [i(1+i)^{Equiplife}] / [(1+i)^{Equiplife} - 1]$

Annual cost = (Capital cost * CRF) + O&M cost

AT-A-GLANCE TABLE FOR POINT SOURCES

The cost effectiveness is determined by dividing the annual cost by the annual tons SO₂ reduced.

Cost Effectiveness: The cost effectiveness is variable depending on stack flow rate in cubic feet per minute.

Comments:

Status: Demonstrated

Last Reviewed: 1999

Additional Information:

Refinery sour gas streams are generally fed to a regenerative type of H₂S removal process. The concentrated acid gas is then sent to the sulfur recovery unit. The Claus process is the most widely used method of producing sulfur from refinery H₂S (Pechan, 1999). The modified Claus process is based on producing elemental sulfur by first converting one-third of the H₂S feed by precise combustion with air. The combustion products are then allowed to react thermally with the remaining two-thirds of the H₂S feed in the presence of a suitable catalyst to form sulfur vapor.

FGD scrubbers can be either wet or dry systems. In wet systems, a liquid sorbent is sprayed into the flue gas in an absorber vessel. Limestone and lime-based reagents are most frequently used in scrubbers in the United States (EPA, 2002). Dry and semi-dry FGD systems include spray dryers, and dry injection into a duct or a combustion zone.

References:

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1999: E.H. Pechan & Associates, Inc., "Control Measure Evaluations: The Control Measure Data Base For the National Emission Trends Inventory (AirControlNET) – Draft Report," prepared for the U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, September 1999.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Sulfur Recovery Plants - Elemental Sulfur

Control Measure Name: Amine Scrubbing

Rule Name: Not Applicable

Pechan Measure Code: S0701

POD: 07

Application: This control is the use of amine scrubbing add-on controls to reduce SO₂ emissions.

This control applies to stage 3 elemental sulfur recovery plants with out control, 95-96% removal.

Affected SCC:

30103202 Chemical, Element Sulfur, Mod. Claus-3Stage w/o Control (95-96% Removal)

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
							√*			

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 98% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Capital and annual costs were developed from model plant data (EPA, 1986). The costs are based on stack flowrate in cubic feet per minute.

Cost equations for amine scrubbing:

Capital cost = \$2,882,540 + \$244.74 * Flow rate

Operating and Maintenance (O&M) cost = \$749,170 + \$148.40 * Flow rate

Equipment Life in Years = Equiplife = 15 years

Interest Rate = I = 7%

Capital Recovery Factor: $CRF = [i(1+i)^{\text{Equiplife}}] / [(1+i)^{\text{Equiplife}} - 1]$

Annual cost = (Capital cost * CRF) + O&M cost

O&M Cost Components: The O&M cost components for amine scrubbing of Claus system tail gas are based on three model plants as given below (EPA, 1983):

Sulfur Intake	Catalytic Recovery	Claus Recovery
10 tons per day	two-stage	95.1%
50 tons per day	three-stage	96.4%
100 tons per day	three-stage	96.4%

There are no disposal costs and a credit for the recovered product. Annual operating days are assumed to be 350 days. The following assumptions apply to the cost of utilities and disposal:

AT-A-GLANCE TABLE FOR POINT SOURCES

Catalyst		
a. alumina	17	\$/cubic feet
b. cobalt-molybdenum	170	\$/cubic feet
Reagent		
a. Diisopropanolamine	1.07	\$/lb
b. Soda	300	\$/ton
Steam	6.00	\$/1000 lb
Steam Condensate	1.25	\$/1000 lb
Water		
a. Boiler	0.05	\$/1000 gal
b. Cooling	1.50	\$/1000 lb
Natural Gas	3.50	\$/MMBtu
Electrical energy	0.05	\$/kWh
Credit for byproduct recovery	1.88	\$/ton

The cost effectiveness is determined by dividing the annual cost by the annual tons SO₂ reduced.

Cost Effectiveness: The cost effectiveness is variable depending on stack flow rate in cubic feet per minute.

Comments:

Status: Demonstrated

Last Reviewed: 1999

Additional Information:

Refinery sour gas streams are generally fed to a regenerative type of H₂S removal process. The concentrated acid gas is then sent to the sulfur recovery unit. The Claus process is the most widely used method of producing sulfur from refinery H₂S (Pechan, 1999). The modified Claus process is based on producing elemental sulfur by first converting one-third of the H₂S feed by precise combustion with air. The combustion products are then allowed to react thermally with the remaining two-thirds of the H₂S feed in the presence of a suitable catalyst to form sulfur vapor.

References:

EPA, 1983: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Review of New Performance Standards for Petroleum Refinery Claus Sulfur Recovery Plants," EPA-450/3-83-014, Research Triangle Park, NC, August 1983.

Emmel, T.E., et al., 1986: "Cost of Controlling Directly Emitted Acidic Emissions from Major Sources," Radian Corporation, Research Triangle Park, NC, (EPA/600/7-88-012), July 1986.

Pechan, 1999: E.H. Pechan & Associates, Inc., "Control Measure Evaluations: The Control Measure Data Base For the National Emission Trends Inventory (AirControlNET) – Draft Report," prepared for the U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, September 1999.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Sulfur Recovery Plants - Elemental Sulfur

Control Measure Name: Amine Scrubbing + Flue Gas Desulfurization

Rule Name: Not Applicable

Pechan Measure Code: S0702

POD: 07

Application: This control is the use of amine scrubbing add-on controls combined with flue gas desulfurization technologies to reduce SO₂ emissions.

This control applies to stage 3 elemental sulfur recovery plants with out control, 95-96% removal.

Affected SCC:

30103202 Chemical, Element Sulfur, Mod. Claus-3Stage w/o Control (95-96% Removal)

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
							√*			

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 99.8% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs are based on stack flowrate in cubic feet per minute. The equations below are simplified from the EPA Control Cost Manual (EPA, 2002).

Cost equations for amine scrubbing and FGD:

Capital cost:

DEF = de-escalation factor (to convert to 1990 dollars) = 0.9383

RF = retrofit factor = 1.1

For stack flowrate less than 1,0280,000 cu. ft./min = 2,882,540 + (244.74 * Flowrate) + ((1,0280,000/Flowrate)^{0.6}) * 93.3*RF*Flowrate*DEF

For stack flowrate greater than or equal to 1,0280,000 cu. ft./min = 2,882,540 + (244.74 * Flowrate) + (93.3*RF*Flowrate*DEF)

Operating and Maintenance (O&M) cost = 749,170 + 148.40 * Flowrate + 3.35+0.000729*8736*DEF * Flowrate

Equipment Life in Years = Equiplife = 15 years

Interest Rate = I = 7%

Capital Recovery Factor: $CRF = [i(1+i)^{Equiplife}] / [(1+i)^{Equiplife} - 1]$

Annual cost = (Capital cost * CRF) + O&M cost

AT-A-GLANCE TABLE FOR POINT SOURCES

The cost effectiveness is determined by dividing the annual cost by the annual tons SO₂ reduced.

Cost Effectiveness: The cost effectiveness is variable depending on stack flow rate in cubic feet per minute.

Comments:

Status: Demonstrated

Last Reviewed: 1999

Additional Information:

Refinery sour gas streams are generally fed to a regenerative type of H₂S removal process. The concentrated acid gas is then sent to the sulfur recovery unit. The Claus process is the most widely used method of producing sulfur from refinery H₂S (Pechan, 1999). The modified Claus process is based on producing elemental sulfur by first converting one-third of the H₂S feed by precise combustion with air. The combustion products are then allowed to react thermally with the remaining two-thirds of the H₂S feed in the presence of a suitable catalyst to form sulfur vapor.

FGD scrubbers can be either wet or dry systems. In wet systems, a liquid sorbent is sprayed into the flue gas in an absorber vessel. Limestone and lime-based reagents are most frequently used in scrubbers in the United States (EPA, 2002). Dry and semi-dry FGD systems include spray dryers, and dry injection into a duct or a combustion zone.

References:

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1999: E.H. Pechan & Associates, Inc., "Control Measure Evaluations: The Control Measure Data Base For the National Emission Trends Inventory (AirControlNET) – Draft Report," prepared for the U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, September 1999.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Sulfur Recovery Plants - Elemental Sulfur

Control Measure Name: Amine Scrubbing

Rule Name: Not Applicable

Pechan Measure Code: S0801

POD: 08

Application: This control is the use of amine scrubbing add-on controls to reduce SO₂ emissions.

This control applies to stage 4 elemental sulfur recovery plants with out control, 96-97% removal.

Affected SCC:

30103203 Elemental Sulfur Production, Mod. Claus: 4 Stage w/o Control (96-97% Removal)

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
							√*			

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 97% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Capital and annual costs were developed from model plant data (EPA, 1986). The costs are based on stack flowrate in cubic feet per minute.

Cost equations for amine scrubbing:

Capital cost = \$2,882,540 + \$244.74 * Flow rate

Operating and Maintenance (O&M) cost = \$749,170 + \$148.40 * Flow rate

Equipment Life in Years = Equiplife = 15 years

Interest Rate = I = 7%

Capital Recovery Factor: $CRF = [i(1+i)^{Equiplife}] / [(1+i)^{Equiplife} - 1]$

Annual cost = (Capital cost * CRF) + O&M cost

O&M Cost Components: The O&M cost components for amine scrubbing of Claus system tail gas are based on three model plants as given below (EPA, 1983):

Sulfur Intake Catalytic Recovery Claus Recovery

10 tons per day two-stage 95.1%

50 tons per day three-stage 96.4%

100 tons per day three-stage 96.4%

There are no disposal costs and a credit for the recovered product. Annual operating days are assumed to be 350 days. The following assumptions apply to the cost of utilities and disposal:

AT-A-GLANCE TABLE FOR POINT SOURCES

Catalyst		
a. alumina	17	\$/cubic feet
b. cobalt-molybdenum	170	\$/cubic feet
Reagent		
a. Diisopropanolamine	1.07	\$/lb
b. Soda	300	\$/ton
Steam	6.00	\$/1000 lb
Steam Condensate	1.25	\$/1000 lb
Water		
a. Boiler	0.05	\$/1000 gal
b. Cooling	1.50	\$/1000 lb
Natural Gas	3.50	\$/MMBtu
Electrical energy	0.05	\$/kWh
Credit for byproduct recovery	1.88	\$/ton

The cost effectiveness is determined by dividing the annual cost by the annual tons SO₂ reduced.

Cost Effectiveness: The cost effectiveness is variable depending on stack flow rate in cubic feet per minute.

Comments:

Status: Demonstrated

Last Reviewed: 1999

Additional Information:

Refinery sour gas streams are generally fed to a regenerative type of H₂S removal process. The concentrated acid gas is then sent to the sulfur recovery unit. The Claus process is the most widely used method of producing sulfur from refinery H₂S (Pechan, 1999). The modified Claus process is based on producing elemental sulfur by first converting one-third of the H₂S feed by precise combustion with air. The combustion products are then allowed to react thermally with the remaining two-thirds of the H₂S feed in the presence of a suitable catalyst to form sulfur vapor.

References:

EPA, 1983: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Review of New Performance Standards for Petroleum Refinery Claus Sulfur Recovery Plants," EPA-450/3-83-014, Research Triangle Park, NC, August 1983.

Emmel, T.E., et al., 1986: "Cost of Controlling Directly Emitted Acidic Emissions from Major Sources," Radian Corporation, Research Triangle Park, NC, (EPA/600/7-88-012), July 1986.

Pechan, 1999: E.H. Pechan & Associates, Inc., "Control Measure Evaluations: The Control Measure Data Base For the National Emission Trends Inventory (AirControlNET) – Draft Report," prepared for the U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, September 1999.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Sulfur Recovery Plants - Elemental Sulfur

Control Measure Name: Amine Scrubbing + Flue Gas Desulfurization

Rule Name: Not Applicable

Pechan Measure Code: S0802

POD: 08

Application: This control is the use of amine scrubbing add-on controls combined with flue gas desulfurization technologies to reduce SO₂ emissions.

This control applies to stage 4 elemental sulfur recovery plants with out control, 96-97% removal.

Affected SCC:

30103203 Elemental Sulfur Production, Mod. Claus: 4 Stage w/o Control (96-97% Removal)

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
							√*			

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 99.7% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs are based on stack flowrate in cubic feet per minute. The equations below are simplified from the EPA Control Cost Manual (EPA, 2002).

Cost equations for amine scrubbing and FGD:

Capital cost:

DEF = de-escalation factor (to convert to 1990 dollars) = 0.9383

RF = retrofit factor = 1.1

For stack flowrate less than 1,0280,000 cu. ft./min = 2,882,540 + (244.74 * Flowrate) + ((1,0280,000/Flowrate)^{0.6}) * 93.3*RF*Flowrate*DEF

For stack flowrate greater than or equal to 1,0280,000 cu. ft./min = 2,882,540 + (244.74 * Flowrate) + (93.3*RF*Flowrate*DEF)

Operating and Maintenance (O&M) cost = 749,170 + 148.40 * Flowrate + 3.35+0.000729*8736*DEF * Flowrate

Equipment Life in Years = Equiplife = 15 years

Interest Rate = I = 7%

Capital Recovery Factor: $CRF = [i(1+i)^{Equiplife}] / [(1+i)^{Equiplife} - 1]$

Annual cost = (Capital cost * CRF) + O&M cost

AT-A-GLANCE TABLE FOR POINT SOURCES

The cost effectiveness is determined by dividing the annual cost by the annual tons SO₂ reduced.

Cost Effectiveness: The cost effectiveness is variable depending on stack flow rate in cubic feet per minute.

Comments:

Status: Demonstrated

Last Reviewed: 1999

Additional Information:

Refinery sour gas streams are generally fed to a regenerative type of H₂S removal process. The concentrated acid gas is then sent to the sulfur recovery unit. The Claus process is the most widely used method of producing sulfur from refinery H₂S (Pechan, 1999). The modified Claus process is based on producing elemental sulfur by first converting one-third of the H₂S feed by precise combustion with air. The combustion products are then allowed to react thermally with the remaining two-thirds of the H₂S feed in the presence of a suitable catalyst to form sulfur vapor.

FGD scrubbers can be either wet or dry systems. In wet systems, a liquid sorbent is sprayed into the flue gas in an absorber vessel. Limestone and lime-based reagents are most frequently used in scrubbers in the United States (EPA, 2002). Dry and semi-dry FGD systems include spray dryers, and dry injection into a duct or a combustion zone.

References:

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

Pechan, 1999: E.H. Pechan & Associates, Inc., "Control Measure Evaluations: The Control Measure Data Base For the National Emission Trends Inventory (AirControlNET) - Draft Report," prepared for the U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, September 1999.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Sulfur Recovery Plants - Elemental Sulfur

Control Measure Name: Flue Gas Desulfurization

Rule Name: Not Applicable

Pechan Measure Code: S1001

POD: 10

Application: This control is the use of flue gas desulfurization technologies to reduce NOx emissions.

This control applies elemental sulfur recovery plants classified under SCC 30103299.

Affected SCC:

30103299 Elemental Sulfur Production, Other Not Classified

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
							√*			

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 90% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs are based on stack flowrate in cubic feet per minute. The equations below are simplified from the EPA Control Cost Manual (EPA, 2002).

Cost equations for flue gas desulfurization:

Capital cost:

DEF = de-escalation factor (to convert to 1990 dollars) = 0.9383

RF = retrofit factor = 1.1

For stack flowrate less than 1,0280,000 cu. ft./min =
 $(1,0280,000/\text{Flowrate})^{0.6} * 93.3 * \text{RF} * \text{Flowrate} * \text{DEF}$

For stack flowrate greater than or equal to 1,0280,000 cu. ft./min =
 $93.3 * \text{RF} * \text{Flowrate} * \text{DEF}$

Operating and Maintenance (O&M) cost = $3.35 + 0.000729 * 8736 * \text{DEF} * \text{Flowrate}$

Equipment Life in Years = Equiplife = 15 years

Interest Rate = I = 7%

Capital Recovery Factor: $\text{CRF} = [i(1+i)^{\text{Equiplife}}] / [(1+i)^{\text{Equiplife}} - 1]$

Annual cost = (Capital cost * CRF) + O&M cost

The cost effectiveness is determined by dividing the annual cost by the annual tons SO2 reduced.

AT-A-GLANCE TABLE FOR POINT SOURCES

Cost Effectiveness: The cost effectiveness is variable depending on stack flow rate in cubic feet per minute.

Comments:

Status: Demonstrated

Last Reviewed: 1999

Additional Information:

FGD scrubbers can be either wet or dry systems. In wet systems, a liquid sorbent is sprayed into the flue gas in an absorber vessel. Limestone and lime-based reagents are most frequently used in scrubbers in the United States (EPA, 2002). Dry and semi-dry FGD systems include spray dryers, and dry injection into a duct or a combustion zone.

References:

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Sulfur Recovery Plants - Sulfur Removal

Control Measure Name: Flue Gas Desulfurization

Rule Name: Not Applicable

Pechan Measure Code: S0901

POD: 09

Application: This control is the use of flue gas desulfurization technologies to reduce NOx emissions.

This control applies to sulfur removal processes at sulfur recovery plants classified under SCC 30103204.

Affected SCC:

30103204 Chem. Manufacturing, Elemental Sulfur Prod., Sulfur Removal (99.9% Removal)

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
							√*			

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 90% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs are based on stack flowrate in cubic feet per minute. The equations below are simplified from the EPA Control Cost Manual (EPA, 2002).

Cost equations for flue gas desulfurization:

Capital cost:

DEF = de-escalation factor (to convert to 1990 dollars) = 0.9383

RF = retrofit factor = 1.1

For stack flowrate less than 1,0280,000 cu. ft./min =
 $(1,0280,000/\text{Flowrate})^{0.6} * 93.3 * \text{RF} * \text{Flowrate} * \text{DEF}$

For stack flowrate greater than or equal to 1,0280,000 cu. ft./min =
 $93.3 * \text{RF} * \text{Flowrate} * \text{DEF}$

Operating and Maintenance (O&M) cost = $3.35 + 0.000729 * 8736 * \text{DEF} * \text{Flowrate}$

Equipment Life in Years = Equiplife = 15 years

Interest Rate = i = 7%

Capital Recovery Factor: $\text{CRF} = [i(1+i)^{\text{Equiplife}}] / [(1+i)^{\text{Equiplife}} - 1]$

Annual cost = (Capital cost * CRF) + O&M cost

The cost effectiveness is determined by dividing the annual cost by the annual tons

AT-A-GLANCE TABLE FOR POINT SOURCES

SO₂ reduced.

Cost Effectiveness: The cost effectiveness is variable depending on stack flow rate in cubic feet per minute.

Comments:

Status: Demonstrated

Last Reviewed: 1999

Additional Information:

FGD scrubbers can be either wet or dry systems. In wet systems, a liquid sorbent is sprayed into the flue gas in an absorber vessel. Limestone and lime-based reagents are most frequently used in scrubbers in the United States (EPA, 2002). Dry and semi-dry FGD systems include spray dryers, and dry injection into a duct or a combustion zone.

References:

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Sulfuric Acid Plants - Contact Absorbers

Control Measure Name: Flue Gas Desulfurization

Rule Name: Not Applicable

Pechan Measure Code: S0101

POD: 01

Application: This control is the use of flue gas desulfurization technologies to reduce SO₂ emissions.

This control applies to contact absorbers at 99% conversion involved in sulfuric acid production classified under SCC 30102301.

Affected SCC:

30102301 Chemical Manufacturing, Sulfuric Acid (Contact Process), Absorber/@ 99.9% Conversion

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
							√*			

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 90% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs are based on stack flowrate in cubic feet per minute. The equations below are simplified from the EPA Control Cost Manual (EPA, 2002).

Cost equations for flue gas desulfurization:

Capital cost:

DEF = de-escalation factor (to convert to 1990 dollars) = 0.9383

RF = retrofit factor = 1.1

For stack flowrate less than 1,0280,000 cu. ft./min =
 $(1,0280,000/\text{Flowrate})^{0.6} * 93.3 * \text{RF} * \text{Flowrate} * \text{DEF}$

For stack flowrate greater than or equal to 1,0280,000 cu. ft./min =
 $93.3 * \text{RF} * \text{Flowrate} * \text{DEF}$

Operating and Maintenance (O&M) cost = $3.35 + 0.000729 * 8736 * \text{DEF} * \text{Flowrate}$

Equipment Life in Years = Equiplife = 15 years

Interest Rate = I = 7%

Capital Recovery Factor: $\text{CRF} = [i(1+i)^{\text{Equiplife}}] / [(1+i)^{\text{Equiplife}} - 1]$

Annual cost = (Capital cost * CRF) + O&M cost

The cost effectiveness is determined by dividing the annual cost by the annual tons

AT-A-GLANCE TABLE FOR POINT SOURCES

SO₂ reduced.

Cost Effectiveness: The cost effectiveness is variable depending on stack flow rate in cubic feet per minute.

Comments:

Status: Demonstrated

Last Reviewed: 1999

Additional Information:

FGD scrubbers can be either wet or dry systems. In wet systems, a liquid sorbent is sprayed into the flue gas in an absorber vessel. Limestone and lime-based reagents are most frequently used in scrubbers in the United States (EPA, 2002). Dry and semi-dry FGD systems include spray dryers, and dry injection into a duct or a combustion zone.

References:

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC, January 2002.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Sulfuric Acid Plants - Contact Absorbers

Control Measure Name: Increase Absorption Efficiency from Existing to NSPS Level (99.7%)

Rule Name: Not Applicable

Pechan Measure Code: S0201

POD: 02

Application: This control is to increase adsorption efficiency from existing to NSPS level (99.7%) to reduce SO₂ emissions.

This control applies to sulfuric acid plants with contact absorption processes at 99% sulfur conversion efficiency.

Affected SCC:

30102306 Sulfuric Acid (Contact Process), Absorber/@ 99.0% Conversion

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
							√*			

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 75% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Capital and annual costs were developed from model plant data (EPA, 1985). The costs are based on stack flowrate in cubic feet per minute.

Cost equations for dual absorption:

Capital cost = \$990,000 + \$9.836 * Flowrate

Operating cost = \$75,800 + \$12.82 * Flowrate

Equipment Life in Years = Equiplife = 15 years

Interest Rate = i = 7%

Capital Recovery Factor: $CRF = [i(1+i)^{Equiplife}] / [(1+i)^{Equiplife} - 1]$

Annual cost = (Capital cost * CRF) + O&M cost

O&M Cost Components: The O&M cost components for dual absorption are based on two model plants with sulfur intake of 750 tons per day and 1,500 tons per day (EPA, 1985). There are no disposal costs and a credit for the recovered product. Annual operating days are assumed to be 350 days. The following assumptions apply to the cost of utilities and disposal:

Water	0.30	\$/cubic meter
Steam	10.50	\$/gJ
Catalyst	8,437,600	\$/cubic meter
Credit for product	1,120	\$/Mg

AT-A-GLANCE TABLE FOR POINT SOURCES

The cost effectiveness is determined by dividing the annual cost by the annual tons SO₂ reduced.

Cost Effectiveness: The cost effectiveness is variable depending on stack flow rate in cubic feet per minute.

Comments:

Status: Demonstrated

Last Reviewed: 1999

Additional Information:

The contact process is used to produce sulfuric acid from waste gas which contains SO₂. First, the waste gas must be pretreated, which usually involves dust removal, cooling, and scrubbing for further removal of particulate matter and heavy metals, mist, and moisture. After pretreatment, the gas is heated and passed through a catalytic converter (platinum mass units or units containing beds of pelletized vanadium pentoxide) to oxidize the SO₂ to SO₃. The exothermic, reversible oxidation reaction results in a conflict between high equilibrium conversions at lower temperatures and high reaction rates at high temperatures. Because of this, the gas is passed between the catalyst and two or three different heat exchangers in order to achieve conversion of SO₂ to SO₃ of about 92.5 to 98 percent. The gas leaving the final catalyst stage is cooled and introduced to an absorption tower by a stream of strong (98 to 99 percent) acid, where the SO₃ reacts with water in the acid to form additional sulfuric acid. Dilute sulfuric acid or water is added to the recirculating acid to maintain the desired concentration (EPA, 1981; EPA, 1997).

The double-contact, or double-absorption, process for making sulfuric acid from waste gas containing SO₂ is essentially the same as the single-contact process with the addition of an interpass absorption tower. The waste gas is cleaned and dried as in the single-contact process before entering the process. Upon leaving the second or third catalyst bed, depending upon the process, the gas is cooled and introduced to a packed-bed, counter-current absorption tower where it contacts 98 to 99 percent sulfuric acid. After the absorbing tower, the gas is reheated and passed to the third or fourth catalyst bed, where approximately 97 percent of the remaining SO₂ is converted to SO₃ and passed to the final absorption tower for conversion to sulfuric acid as in the single-contact process. No cost data were available for either single- or double-contact sulfuric acid plants controls (EPA, 1981; EPA, 1997).

References:

EPA, 1985: U.S. Environmental Protection Agency, "Sulfuric Acid: Review of New Source Performance Standards for Sulfuric Acid Plants," Research Triangle Park, NC, (EPA/450/3-85/012), March 1985.

EPA, 1981: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Control Techniques for Sulfur Oxide Emissions from Stationary Sources," Second Edition, Research Triangle Park, NC, April 1981.

EPA, 1997: U.S. Environmental Protection Agency, "Compilation of Air Pollutant Emission Factors, Volume I, Stationary Point and Area Sources," AP-42, Fifth Edition, Research Triangle Park, NC, October 1997.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Sulfuric Acid Plants - Contact Absorbers

Control Measure Name: Increase Absorption Efficiency from Existing to NSPS Level (99.7%) + Flue Gas Desulfurization

Rule Name: Not Applicable

Pechan Measure Code: S0202

POD: 02

Application: This control is to increase adsorption efficiency from existing to NSPS level (99.7%) and the addition of flue gas desulfurization technologies to reduce SO₂ emissions.

This control applies to sulfuric acid plants with contact absorption processes at 99% sulfur conversion efficiency.

Affected SCC:

30102306 Sulfuric Acid (Contact Process), Absorber/@ 99.0% Conversion

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
							√/*			

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 75% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs are based on stack flowrate in cubic feet per minute. The equations below are simplified from the EPA Control Cost Manual (EPA, 2002).

Cost equations for dual absorption and flue gas desulfurization:

Capital cost:

DEF = de-escalation factor (to convert to 1990 dollars) = 0.9383

RF = retrofit factor = 1.1

For stack flowrate less than 1,0280,000 cu. ft./min = 990,000 + (9.836 * Flowrate) + ((1,0280,000/Flowrate)^{0.6})*93.3*RF*Flowrate*DEF

For stack flowrate greater than or equal to 1,0280,000 cu. ft./min = 990,000 + (9.836 * Flowrate) + (93.3*RF*Flowrate*DEF)

Operating and Maintenance (O&M) cost = 75,800 + 12.82 * Flowrate + 3.35+0.000729*8736*DEF * Flowrate

Equipment Life in Years = Equiplife = 15 years

Interest Rate = I = 7%

Capital Recovery Factor: CRF = [i (1 + i) ^ Equiplife] / [((1 + i) ^ Equiplife) - 1

AT-A-GLANCE TABLE FOR POINT SOURCES

Annual cost = (Capital cost * CRF) + O&M cost

The cost effectiveness is determined by dividing the annual cost by the annual tons SO₂ reduced.

Cost Effectiveness: The cost effectiveness is variable depending on stack flow rate in cubic feet per minute.

Comments:

Status: Demonstrated

Last Reviewed: 1999

Additional Information:

FGD scrubbers can be either wet or dry systems. In wet systems, a liquid sorbent is sprayed into the flue gas in an absorber vessel. Limestone and lime-based reagents are most frequently used in scrubbers in the United States (EPA, 2002). Dry and semi-dry FGD systems include spray dryers, and dry injection into a duct or a combustion zone.

The contact process is used to produce sulfuric acid from waste gas which contains SO₂. First, the waste gas must be pretreated, which usually involves dust removal, cooling, and scrubbing for further removal of particulate matter and heavy metals, mist, and moisture. After pretreatment, the gas is heated and passed through a catalytic converter (platinum mass units or units containing beds of pelletized vanadium pentoxide) to oxidize the SO₂ to SO₃. The exothermic, reversible oxidation reaction results in a conflict between high equilibrium conversions at lower temperatures and high reaction rates at high temperatures. Because of this, the gas is passed between the catalyst and two or three different heat exchangers in order to achieve conversion of SO₂ to SO₃ of about 92.5 to 98 percent. The gas leaving the final catalyst stage is cooled and introduced to an absorption tower by a stream of strong (98 to 99 percent) acid, where the SO₃ reacts with water in the acid to form additional sulfuric acid. Dilute sulfuric acid or water is added to the recirculating acid to maintain the desired concentration (EPA, 1981; EPA, 1997).

The double-contact, or double-absorption, process for making sulfuric acid from waste gas containing SO₂ is essentially the same as the single-contact process with the addition of an interpass absorption tower. The waste gas is cleaned and dried as in the single-contact process before entering the process. Upon leaving the second or third catalyst bed, depending upon the process, the gas is cooled and introduced to a packed-bed, counter-current absorption tower where it contacts 98 to 99 percent sulfuric acid. After the absorbing tower, the gas is reheated and passed to the third or fourth catalyst bed, where approximately 97 percent of the remaining SO₂ is converted to SO₃ and passed to the final absorption tower for conversion to sulfuric acid as in the single-contact process. No cost data were available for either single- or double-contact sulfuric acid plants controls (EPA, 1981; EPA, 1997).

References:

EPA, 1981: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Control Techniques for Sulfur Oxide Emissions from Stationary Sources," Second Edition, Research Triangle Park, NC, April 1981.

EPA, 1997: U.S. Environmental Protection Agency, "Compilation of Air Pollutant Emission Factors, Volume I, Stationary Point and Area Sources," AP-42, Fifth Edition, Research Triangle Park, NC, October 1997.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC,

AT-A-GLANCE TABLE FOR POINT SOURCES

January 2002.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Sulfuric Acid Plants - Contact Absorbers

Control Measure Name: Increase Absorption Efficiency from Existing to NSPS Level (99.7%)

Rule Name: Not Applicable

Pechan Measure Code: S0301

POD: 03

Application: This control is to increase adsorption efficiency from existing to NSPS level (99.7%) to reduce SO₂ emissions.

This control applies to sulfuric acid plants with contact absorption processes at 98% sulfur conversion efficiency.

Affected SCC:

30102308 Sulfuric Acid (Contact Process), Absorber/@ 98.0% Conversion

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
							√*			

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 85% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Capital and annual costs were developed from model plant data (EPA, 1985). The costs are based on stack flowrate in cubic feet per minute.

Cost equations for dual absorption:

Capital cost = \$990,000 + \$9.836 * Flowrate

Operating cost = \$75,800 + \$12.82 * Flowrate

Equipment Life in Years = Equiplife = 15 years

Interest Rate = i = 7%

Capital Recovery Factor: $CRF = [i(1+i)^{Equiplife}] / [(1+i)^{Equiplife} - 1]$

Annual cost = (Capital cost * CRF) + O&M cost

O&M Cost Components: The O&M cost components for dual absorption are based on two model plants with sulfur intake of 750 tons per day and 1,500 tons per day (EPA, 1985). There are no disposal costs and a credit for the recovered product. Annual operating days are assumed to be 350 days. The following assumptions apply to the cost of utilities and disposal:

Water	0.30	\$/cubic meter
Steam	10.50	\$/gJ
Catalyst	8,437,600	\$/cubic meter
Credit for product	1,120	\$/Mg

AT-A-GLANCE TABLE FOR POINT SOURCES

The cost effectiveness is determined by dividing the annual cost by the annual tons SO₂ reduced.

Cost Effectiveness: The cost effectiveness is variable depending on stack flow rate in cubic feet per minute.

Comments:

Status: Demonstrated

Last Reviewed: 1999

Additional Information:

The contact process is used to produce sulfuric acid from waste gas which contains SO₂. First, the waste gas must be pretreated, which usually involves dust removal, cooling, and scrubbing for further removal of particulate matter and heavy metals, mist, and moisture. After pretreatment, the gas is heated and passed through a catalytic converter (platinum mass units or units containing beds of pelletized vanadium pentoxide) to oxidize the SO₂ to SO₃. The exothermic, reversible oxidation reaction results in a conflict between high equilibrium conversions at lower temperatures and high reaction rates at high temperatures. Because of this, the gas is passed between the catalyst and two or three different heat exchangers in order to achieve conversion of SO₂ to SO₃ of about 92.5 to 98 percent. The gas leaving the final catalyst stage is cooled and introduced to an absorption tower by a stream of strong (98 to 99 percent) acid, where the SO₃ reacts with water in the acid to form additional sulfuric acid. Dilute sulfuric acid or water is added to the recirculating acid to maintain the desired concentration (EPA, 1981; EPA, 1997).

The double-contact, or double-absorption, process for making sulfuric acid from waste gas containing SO₂ is essentially the same as the single-contact process with the addition of an interpass absorption tower. The waste gas is cleaned and dried as in the single-contact process before entering the process. Upon leaving the second or third catalyst bed, depending upon the process, the gas is cooled and introduced to a packed-bed, counter-current absorption tower where it contacts 98 to 99 percent sulfuric acid. After the absorbing tower, the gas is reheated and passed to the third or fourth catalyst bed, where approximately 97 percent of the remaining SO₂ is converted to SO₃ and passed to the final absorption tower for conversion to sulfuric acid as in the single-contact process. No cost data were available for either single- or double-contact sulfuric acid plants controls (EPA, 1981; EPA, 1997).

References:

EPA, 1985: U.S. Environmental Protection Agency, "Sulfuric Acid: Review of New Source Performance Standards for Sulfuric Acid Plants," Research Triangle Park, NC, (EPA/450/3-85/012), March 1985.

EPA, 1981: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Control Techniques for Sulfur Oxide Emissions from Stationary Sources," Second Edition, Research Triangle Park, NC, April 1981.

EPA, 1997: U.S. Environmental Protection Agency, "Compilation of Air Pollutant Emission Factors, Volume I, Stationary Point and Area Sources," AP-42, Fifth Edition, Research Triangle Park, NC, October 1997.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Sulfuric Acid Plants - Contact Absorbers

Control Measure Name: Increase Absorption Efficiency from Existing to NSPS Level (99.7%) + Flue Gas Desulfurization

Rule Name: Not Applicable

Pechan Measure Code: S0302

POD: 03

Application: This control is to increase adsorption efficiency from existing to NSPS level (99.7%) and the addition of flue gas desulfurization technologies to reduce SO₂ emissions.

This control applies to sulfuric acid plants with contact absorption processes at 98% sulfur conversion efficiency.

Affected SCC:

30102308 Sulfuric Acid (Contact Process), Absorber/@ 98.0% Conversion

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
							√*			

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 85% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs are based on stack flowrate in cubic feet per minute. The equations below are simplified from the EPA Control Cost Manual (EPA, 2002).

Cost equations for dual absorption and flue gas desulfurization:

Capital cost:

DEF = de-escalation factor (to convert to 1990 dollars) = 0.9383

RF = retrofit factor = 1.1

For stack flowrate less than 1,0280,000 cu. ft./min = $990,000 + (9.836 * \text{Flowrate}) + ((1,0280,000/\text{Flowrate})^{0.6}) * 93.3 * \text{RF} * \text{Flowrate} * \text{DEF}$

For stack flowrate greater than or equal to 1,0280,000 cu. ft./min = $990,000 + (9.836 * \text{Flowrate}) + (93.3 * \text{RF} * \text{Flowrate} * \text{DEF})$

Operating and Maintenance (O&M) cost = $75,800 + 12.82 * \text{Flowrate} + 3.35 + 0.000729 * 8736 * \text{DEF} * \text{Flowrate}$

Equipment Life in Years = Equiplife = 15 years

Interest Rate = I = 7%

Capital Recovery Factor: $\text{CRF} = [i(1+i)^{\text{Equiplife}}] / [(1+i)^{\text{Equiplife}} - 1]$

AT-A-GLANCE TABLE FOR POINT SOURCES

Annual cost = (Capital cost * CRF) + O&M cost

The cost effectiveness is determined by dividing the annual cost by the annual tons SO₂ reduced.

Cost Effectiveness: The cost effectiveness is variable depending on stack flow rate in cubic feet per minute.

Comments:

Status: Demonstrated

Last Reviewed: 1999

Additional Information:

FGD scrubbers can be either wet or dry systems. In wet systems, a liquid sorbent is sprayed into the flue gas in an absorber vessel. Limestone and lime-based reagents are most frequently used in scrubbers in the United States (EPA, 2002). Dry and semi-dry FGD systems include spray dryers, and dry injection into a duct or a combustion zone.

The contact process is used to produce sulfuric acid from waste gas which contains SO₂. First, the waste gas must be pretreated, which usually involves dust removal, cooling, and scrubbing for further removal of particulate matter and heavy metals, mist, and moisture. After pretreatment, the gas is heated and passed through a catalytic converter (platinum mass units or units containing beds of pelletized vanadium pentoxide) to oxidize the SO₂ to SO₃. The exothermic, reversible oxidation reaction results in a conflict between high equilibrium conversions at lower temperatures and high reaction rates at high temperatures. Because of this, the gas is passed between the catalyst and two or three different heat exchangers in order to achieve conversion of SO₂ to SO₃ of about 92.5 to 98 percent. The gas leaving the final catalyst stage is cooled and introduced to an absorption tower by a stream of strong (98 to 99 percent) acid, where the SO₃ reacts with water in the acid to form additional sulfuric acid. Dilute sulfuric acid or water is added to the recirculating acid to maintain the desired concentration (EPA, 1981; EPA, 1997).

The double-contact, or double-absorption, process for making sulfuric acid from waste gas containing SO₂ is essentially the same as the single-contact process with the addition of an interpass absorption tower. The waste gas is cleaned and dried as in the single-contact process before entering the process. Upon leaving the second or third catalyst bed, depending upon the process, the gas is cooled and introduced to a packed-bed, counter-current absorption tower where it contacts 98 to 99 percent sulfuric acid. After the absorbing tower, the gas is reheated and passed to the third or fourth catalyst bed, where approximately 97 percent of the remaining SO₂ is converted to SO₃ and passed to the final absorption tower for conversion to sulfuric acid as in the single-contact process. No cost data were available for either single- or double-contact sulfuric acid plants controls (EPA, 1981; EPA, 1997).

References:

EPA, 1981: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Control Techniques for Sulfur Oxide Emissions from Stationary Sources," Second Edition, Research Triangle Park, NC, April 1981.

EPA, 1997: U.S. Environmental Protection Agency, "Compilation of Air Pollutant Emission Factors, Volume I, Stationary Point and Area Sources," AP-42, Fifth Edition, Research Triangle Park, NC, October 1997.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC,

AT-A-GLANCE TABLE FOR POINT SOURCES

January 2002.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Sulfuric Acid Plants - Contact Absorbers

Control Measure Name: Increase Absorption Efficiency from Existing to NSPS Level (99.7%)

Rule Name: Not Applicable

Pechan Measure Code: S0401

POD: 04

Application: This control is to increase adsorption efficiency from existing to NSPS level (99.7%) to reduce SO₂ emissions.

This control applies to sulfuric acid plants with contact absorption processes at 97% sulfur conversion efficiency.

Affected SCC:

30102310 Sulfuric Acid (Contact Process), Absorber/@ 97.0% Conversion

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
							√*			

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 90% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Capital and annual costs were developed from model plant data (EPA, 1985). The costs are based on stack flowrate in cubic feet per minute.

Cost equations for dual absorption:

Capital cost = \$990,000 + \$9.836 * Flowrate

Operating cost = \$75,800 + \$12.82 * Flowrate

Equipment Life in Years = Equiplife = 15 years

Interest Rate = I = 7%

Capital Recovery Factor: $CRF = [i(1+i)^{Equiplife}] / [(1+i)^{Equiplife} - 1]$

Annual cost = (Capital cost * CRF) + O&M cost

O&M Cost Components: The O&M cost components for dual absorption are based on two model plants with sulfur intake of 750 tons per day and 1,500 tons per day (EPA, 1985). There are no disposal costs and a credit for the recovered product. Annual operating days are assumed to be 350 days. The following assumptions apply to the cost of utilities and disposal:

Water	0.30	\$/cubic meter
Steam	10.50	\$/gJ
Catalyst	8,437,600	\$/cubic meter
Credit for product	1,120	\$/Mg

AT-A-GLANCE TABLE FOR POINT SOURCES

The cost effectiveness is determined by dividing the annual cost by the annual tons SO₂ reduced.

Cost Effectiveness: The cost effectiveness is variable depending on stack flow rate in cubic feet per minute.

Comments:

Status: Demonstrated

Last Reviewed: 1999

Additional Information:

The contact process is used to produce sulfuric acid from waste gas which contains SO₂. First, the waste gas must be pretreated, which usually involves dust removal, cooling, and scrubbing for further removal of particulate matter and heavy metals, mist, and moisture. After pretreatment, the gas is heated and passed through a catalytic converter (platinum mass units or units containing beds of pelletized vanadium pentoxide) to oxidize the SO₂ to SO₃. The exothermic, reversible oxidation reaction results in a conflict between high equilibrium conversions at lower temperatures and high reaction rates at high temperatures. Because of this, the gas is passed between the catalyst and two or three different heat exchangers in order to achieve conversion of SO₂ to SO₃ of about 92.5 to 98 percent. The gas leaving the final catalyst stage is cooled and introduced to an absorption tower by a stream of strong (98 to 99 percent) acid, where the SO₃ reacts with water in the acid to form additional sulfuric acid. Dilute sulfuric acid or water is added to the recirculating acid to maintain the desired concentration (EPA, 1981; EPA, 1997).

The double-contact, or double-absorption, process for making sulfuric acid from waste gas containing SO₂ is essentially the same as the single-contact process with the addition of an interpass absorption tower. The waste gas is cleaned and dried as in the single-contact process before entering the process. Upon leaving the second or third catalyst bed, depending upon the process, the gas is cooled and introduced to a packed-bed, counter-current absorption tower where it contacts 98 to 99 percent sulfuric acid. After the absorbing tower, the gas is reheated and passed to the third or fourth catalyst bed, where approximately 97 percent of the remaining SO₂ is converted to SO₃ and passed to the final absorption tower for conversion to sulfuric acid as in the single-contact process. No cost data were available for either single- or double-contact sulfuric acid plants controls (EPA, 1981; EPA, 1997).

References:

EPA, 1985: U.S. Environmental Protection Agency, "Sulfuric Acid: Review of New Source Performance Standards for Sulfuric Acid Plants," Research Triangle Park, NC, (EPA/450/3-85/012), March 1985.

EPA, 1981: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Control Techniques for Sulfur Oxide Emissions from Stationary Sources," Second Edition, Research Triangle Park, NC, April 1981.

EPA, 1997: U.S. Environmental Protection Agency, "Compilation of Air Pollutant Emission Factors, Volume I, Stationary Point and Area Sources," AP-42, Fifth Edition, Research Triangle Park, NC, October 1997.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Sulfuric Acid Plants - Contact Absorbers

Control Measure Name: Increase Absorption Efficiency from Existing to NSPS Level (99.7%) + Flue Gas Desulfurization

Rule Name: Not Applicable

Pechan Measure Code: S0402

POD: 04

Application: This control is to increase adsorption efficiency from existing to NSPS level (99.7%) and the addition of flue gas desulfurization technologies to reduce SO₂ emissions.

This control applies to sulfuric acid plants with contact absorption processes at 97% sulfur conversion efficiency.

Affected SCC:

30102310 Sulfuric Acid (Contact Process), Absorber/@ 97.0% Conversion

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
							√*			

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 90% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs are based on stack flowrate in cubic feet per minute. The equations below are simplified from the EPA Control Cost Manual (EPA, 2002).

Cost equations for dual absorption and flue gas desulfurization:

Capital cost:

DEF = de-escalation factor (to convert to 1990 dollars) = 0.9383

RF = retrofit factor = 1.1

For stack flowrate less than 1,0280,000 cu. ft./min = 990,000 + (9.836 * Flowrate) + ((1,0280,000/Flowrate)^{0.6})*93.3*RF*Flowrate*DEF

For stack flowrate greater than or equal to 1,0280,000 cu. ft./min = 990,000 + (9.836 * Flowrate) + (93.3*RF*Flowrate*DEF)

Operating and Maintenance (O&M) cost = 75,800 + 12.82 * Flowrate + 3.35+0.000729*8736*DEF * Flowrate

Equipment Life in Years = Equiplife = 15 years

Interest Rate = I = 7%

Capital Recovery Factor: CRF = [i (1 + i) ^ Equiplife] / [((1 + i) ^ Equiplife) - 1

AT-A-GLANCE TABLE FOR POINT SOURCES

Annual cost = (Capital cost * CRF) + O&M cost

The cost effectiveness is determined by dividing the annual cost by the annual tons SO₂ reduced.

Cost Effectiveness: The cost effectiveness is variable depending on stack flow rate in cubic feet per minute.

Comments:

Status: Demonstrated

Last Reviewed: 1999

Additional Information:

FGD scrubbers can be either wet or dry systems. In wet systems, a liquid sorbent is sprayed into the flue gas in an absorber vessel. Limestone and lime-based reagents are most frequently used in scrubbers in the United States (EPA, 2002). Dry and semi-dry FGD systems include spray dryers, and dry injection into a duct or a combustion zone.

The contact process is used to produce sulfuric acid from waste gas which contains SO₂. First, the waste gas must be pretreated, which usually involves dust removal, cooling, and scrubbing for further removal of particulate matter and heavy metals, mist, and moisture. After pretreatment, the gas is heated and passed through a catalytic converter (platinum mass units or units containing beds of pelletized vanadium pentoxide) to oxidize the SO₂ to SO₃. The exothermic, reversible oxidation reaction results in a conflict between high equilibrium conversions at lower temperatures and high reaction rates at high temperatures. Because of this, the gas is passed between the catalyst and two or three different heat exchangers in order to achieve conversion of SO₂ to SO₃ of about 92.5 to 98 percent. The gas leaving the final catalyst stage is cooled and introduced to an absorption tower by a stream of strong (98 to 99 percent) acid, where the SO₃ reacts with water in the acid to form additional sulfuric acid. Dilute sulfuric acid or water is added to the recirculating acid to maintain the desired concentration (EPA, 1981; EPA, 1997).

The double-contact, or double-absorption, process for making sulfuric acid from waste gas containing SO₂ is essentially the same as the single-contact process with the addition of an interpass absorption tower. The waste gas is cleaned and dried as in the single-contact process before entering the process. Upon leaving the second or third catalyst bed, depending upon the process, the gas is cooled and introduced to a packed-bed, counter-current absorption tower where it contacts 98 to 99 percent sulfuric acid. After the absorbing tower, the gas is reheated and passed to the third or fourth catalyst bed, where approximately 97 percent of the remaining SO₂ is converted to SO₃ and passed to the final absorption tower for conversion to sulfuric acid as in the single-contact process. No cost data were available for either single- or double-contact sulfuric acid plants controls (EPA, 1981; EPA, 1997).

References:

EPA, 1981: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Control Techniques for Sulfur Oxide Emissions from Stationary Sources," Second Edition, Research Triangle Park, NC, April 1981.

EPA, 1997: U.S. Environmental Protection Agency, "Compilation of Air Pollutant Emission Factors, Volume I, Stationary Point and Area Sources," AP-42, Fifth Edition, Research Triangle Park, NC, October 1997.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC,

AT-A-GLANCE TABLE FOR POINT SOURCES

January 2002.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Sulfuric Acid Plants - Contact Absorbers

Control Measure Name: Increase Absorption Efficiency from Existing to NSPS Level (99.7%)

Rule Name: Not Applicable

Pechan Measure Code: S0501

POD: 05

Application: This control is to increase adsorption efficiency from existing to NSPS level (99.7%) to reduce SO₂ emissions.

This control applies to sulfuric acid plants with contact absorption processes at 93% sulfur conversion efficiency.

Affected SCC:

30102318 Sulfuric Acid (Contact Process), Absorber/@ 93.0% Conversion

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
							√*			

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 95% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Capital and annual costs were developed from model plant data (EPA, 1985). The costs are based on stack flowrate in cubic feet per minute.

Cost equations for dual absorption:

Capital cost = \$990,000 + \$9.836 * Flowrate

Operating cost = \$75,800 + \$12.82 * Flowrate

Equipment Life in Years = Equiplife = 15 years

Interest Rate = i = 7%

Capital Recovery Factor: $CRF = [i(1+i)^{Equiplife}] / [(1+i)^{Equiplife} - 1]$

Annual cost = (Capital cost * CRF) + O&M cost

O&M Cost Components: The O&M cost components for dual absorption are based on two model plants with sulfur intake of 750 tons per day and 1,500 tons per day (EPA, 1985). There are no disposal costs and a credit for the recovered product. Annual operating days are assumed to be 350 days. The following assumptions apply to the cost of utilities and disposal:

Water	0.30	\$/cubic meter
Steam	10.50	\$/gJ
Catalyst	8,437,600	\$/cubic meter
Credit for product	1,120	\$/Mg

AT-A-GLANCE TABLE FOR POINT SOURCES

The cost effectiveness is determined by dividing the annual cost by the annual tons SO₂ reduced.

Cost Effectiveness: The cost effectiveness is variable depending on stack flow rate in cubic feet per minute.

Comments:

Status: Demonstrated

Last Reviewed: 1999

Additional Information:

The contact process is used to produce sulfuric acid from waste gas which contains SO₂. First, the waste gas must be pretreated, which usually involves dust removal, cooling, and scrubbing for further removal of particulate matter and heavy metals, mist, and moisture. After pretreatment, the gas is heated and passed through a catalytic converter (platinum mass units or units containing beds of pelletized vanadium pentoxide) to oxidize the SO₂ to SO₃. The exothermic, reversible oxidation reaction results in a conflict between high equilibrium conversions at lower temperatures and high reaction rates at high temperatures. Because of this, the gas is passed between the catalyst and two or three different heat exchangers in order to achieve conversion of SO₂ to SO₃ of about 92.5 to 98 percent. The gas leaving the final catalyst stage is cooled and introduced to an absorption tower by a stream of strong (98 to 99 percent) acid, where the SO₃ reacts with water in the acid to form additional sulfuric acid. Dilute sulfuric acid or water is added to the recirculating acid to maintain the desired concentration (EPA, 1981; EPA, 1997).

The double-contact, or double-absorption, process for making sulfuric acid from waste gas containing SO₂ is essentially the same as the single-contact process with the addition of an interpass absorption tower. The waste gas is cleaned and dried as in the single-contact process before entering the process. Upon leaving the second or third catalyst bed, depending upon the process, the gas is cooled and introduced to a packed-bed, counter-current absorption tower where it contacts 98 to 99 percent sulfuric acid. After the absorbing tower, the gas is reheated and passed to the third or fourth catalyst bed, where approximately 97 percent of the remaining SO₂ is converted to SO₃ and passed to the final absorption tower for conversion to sulfuric acid as in the single-contact process. No cost data were available for either single- or double-contact sulfuric acid plants controls (EPA, 1981; EPA, 1997).

References:

EPA, 1985: U.S. Environmental Protection Agency, "Sulfuric Acid: Review of New Source Performance Standards for Sulfuric Acid Plants," Research Triangle Park, NC, (EPA/450/3-85/012), March 1985.

EPA, 1981: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Control Techniques for Sulfur Oxide Emissions from Stationary Sources," Second Edition, Research Triangle Park, NC, April 1981.

EPA, 1997: U.S. Environmental Protection Agency, "Compilation of Air Pollutant Emission Factors, Volume I, Stationary Point and Area Sources," AP-42, Fifth Edition, Research Triangle Park, NC, October 1997.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Sulfuric Acid Plants - Contact Absorbers

Control Measure Name: Increase Absorption Efficiency from Existing to NSPS Level (99.7%) + Flue Gas Desulfurization

Rule Name: Not Applicable

Pechan Measure Code: S0502

POD: 05

Application: This control is to increase adsorption efficiency from existing to NSPS level (99.7%) and the addition of flue gas desulfurization technologies to reduce SO₂ emissions.

This control applies to sulfuric acid plants with contact absorption processes at 93% sulfur conversion efficiency.

Affected SCC:

30102318 Sulfuric Acid (Contact Process), Absorber/@ 93.0% Conversion

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
							√*			

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 95% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs are based on stack flowrate in cubic feet per minute. The equations below are simplified from the EPA Control Cost Manual (EPA, 2002).

Cost equations for dual absorption and flue gas desulfurization:

Capital cost:

DEF = de-escalation factor (to convert to 1990 dollars) = 0.9383

RF = retrofit factor = 1.1

For stack flowrate less than 1,0280,000 cu. ft./min = $990,000 + (9.836 * \text{Flowrate}) + ((1,0280,000/\text{Flowrate})^{0.6}) * 93.3 * \text{RF} * \text{Flowrate} * \text{DEF}$

For stack flowrate greater than or equal to 1,0280,000 cu. ft./min = $990,000 + (9.836 * \text{Flowrate}) + (93.3 * \text{RF} * \text{Flowrate} * \text{DEF})$

Operating and Maintenance (O&M) cost = $75,800 + 12.82 * \text{Flowrate} + 3.35 + 0.000729 * 8736 * \text{DEF} * \text{Flowrate}$

Equipment Life in Years = Equiplife = 15 years

Interest Rate = I = 7%

Capital Recovery Factor: $\text{CRF} = [i(1+i)^{\text{Equiplife}}] / [(1+i)^{\text{Equiplife}} - 1]$

AT-A-GLANCE TABLE FOR POINT SOURCES

Annual cost = (Capital cost * CRF) + O&M cost

The cost effectiveness is determined by dividing the annual cost by the annual tons SO₂ reduced.

Cost Effectiveness: The cost effectiveness is variable depending on stack flow rate in cubic feet per minute.

Comments:

Status: Demonstrated

Last Reviewed: 1999

Additional Information:

FGD scrubbers can be either wet or dry systems. In wet systems, a liquid sorbent is sprayed into the flue gas in an absorber vessel. Limestone and lime-based reagents are most frequently used in scrubbers in the United States (EPA, 2002). Dry and semi-dry FGD systems include spray dryers, and dry injection into a duct or a combustion zone.

The contact process is used to produce sulfuric acid from waste gas which contains SO₂. First, the waste gas must be pretreated, which usually involves dust removal, cooling, and scrubbing for further removal of particulate matter and heavy metals, mist, and moisture. After pretreatment, the gas is heated and passed through a catalytic converter (platinum mass units or units containing beds of pelletized vanadium pentoxide) to oxidize the SO₂ to SO₃. The exothermic, reversible oxidation reaction results in a conflict between high equilibrium conversions at lower temperatures and high reaction rates at high temperatures. Because of this, the gas is passed between the catalyst and two or three different heat exchangers in order to achieve conversion of SO₂ to SO₃ of about 92.5 to 98 percent. The gas leaving the final catalyst stage is cooled and introduced to an absorption tower by a stream of strong (98 to 99 percent) acid, where the SO₃ reacts with water in the acid to form additional sulfuric acid. Dilute sulfuric acid or water is added to the recirculating acid to maintain the desired concentration (EPA, 1981; EPA, 1997).

The double-contact, or double-absorption, process for making sulfuric acid from waste gas containing SO₂ is essentially the same as the single-contact process with the addition of an interpass absorption tower. The waste gas is cleaned and dried as in the single-contact process before entering the process. Upon leaving the second or third catalyst bed, depending upon the process, the gas is cooled and introduced to a packed-bed, counter-current absorption tower where it contacts 98 to 99 percent sulfuric acid. After the absorbing tower, the gas is reheated and passed to the third or fourth catalyst bed, where approximately 97 percent of the remaining SO₂ is converted to SO₃ and passed to the final absorption tower for conversion to sulfuric acid as in the single-contact process. No cost data were available for either single- or double-contact sulfuric acid plants controls (EPA, 1981; EPA, 1997).

References:

EPA, 1981: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Control Techniques for Sulfur Oxide Emissions from Stationary Sources," Second Edition, Research Triangle Park, NC, April 1981.

EPA, 1997: U.S. Environmental Protection Agency, "Compilation of Air Pollutant Emission Factors, Volume I, Stationary Point and Area Sources," AP-42, Fifth Edition, Research Triangle Park, NC, October 1997.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual," 6th ed., EPA/452/B-02-001, Research Triangle Park, NC,

AT-A-GLANCE TABLE FOR POINT SOURCES

January 2002.

AT-A-GLANCE TABLE FOR UTILITY SOURCES

Source Category: Utility Boilers - Coal-Fired

Control Measure Name: Repowering to IGCC

Rule Name: Not Applicable

Pechan Measure Code: SUT-R

POD: H

Application: Repowering is the integration of new technologies into existing power plant sites to improve boiler and generation efficiency, thus reducing SO₂ emissions.

This control is applicable to electricity generating sources powered by pulverized dry-bottom and bituminous/subbituminous coal.

Affected SCC:

10100202 Electric Generation, Pulverized-Dry Bottom (Bituminous Coal)

10100203 Electric Generation, Bituminous/Subbituminous Coal, Cyclone Furnace (Bituminous)

10100212 Electric Generation, Pulverized Coal-Dry Bottom (Tangential) (Bituminous Coal)

10100217 Bituminous/Subbituminous Coal, Atm. Fluidized Bed Combustion-Bubbling (Bituminous)

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					√		√*			√

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: The control efficiency varies by pollutant: SO₂ (99%); NO_x (25%); Hg (90%)

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Control cost equations used for estimating the costs of repowering utility boilers were developed for electric utility boilers. The cost equations used in this analysis are based on cost equations developed to scale costs to smaller or larger boilers than the model plant (EPA, 2002). Model plants were considered to have boiler design capacities of 500 MW. Several simplifying assumptions were made in developing the costing parameters used for this analysis. A capacity utilization factor of 65 percent were assumed, as well as a 7-percent discount rate and 15-year lifetime of the repowering equipment. A control efficiency of 99 percent was assumed for repowering on all utility boiler fuel types (EPA, 1998).

Capital Costs (CC):

Nameplate Capacity: netdc [=] MW

Total Capital Costs: TCC = \$1,566 per kW

Scaling Factor: SF = (sfn / netdc)^{sfe} = (500 / MW)^{0.6}

CC (for netdc < 500) = TCC * netdc * 1000 * SF

CC (for netdc > 500) = TCC * netdc * 1000

Operating & Maintenance (O&M):

Fixed O&M: omf = \$25.44 per kW per year

Variable O&M: omv = \$2.42 millions per kW-hr

AT-A-GLANCE TABLE FOR UTILITY SOURCES

Capacity Factor: $\text{capfac} = 0.65$

$\text{O\&M} = (\text{omf} * \text{netdc} * 1000) + (\text{omv} * \text{netdc} * 1000 * \text{capfac} * 8760 / 1000)$

Equipment Life in Years = Equiplife

Interest Rate = i

Capital Recovery Factor: $\text{CRF} = [i(1+i)^{\text{Equiplife}}] / [(1+i)^{\text{Equiplife}} - 1]$

Total Cost = $(\text{CRF} * \text{CC}) + \text{O\&M}$

Note: All costs are in 1997 dollars.

Cost Effectiveness: Cost effectiveness varies depending on the nameplate capacity (in MW). The cost effectiveness depends on the following factors: total capital costs of \$783 per kW; fixed O&M costs of \$25.44 per kW per year; and variable O&M costs of \$2.42 mills per kW-hr (1997\$).

Comments:

Status: Demonstrated

Last Reviewed: 2003

Additional Information:

There are several repowering options available to the utilities. Examples include coal to combined cycle and coal to integrated gasification combined cycle (IGCC). Repowering improves power plant efficiencies and implies significant waste reduction from the new systems relative to the performance of technologies in widespread commercial use as of November 1990 (EPA, 1994). For example an existing coal-fired plant can convert into a natural gas-combined cycle plant, resulting in higher plant efficiency and yield lower NO_x, PM and SO₂ emissions.

Typical repowering entails steps in which the coal handling system and the boiler are replaced with new combustion turbines and a heat recovery boiler. The only significant part of the plant that is maintained is the original turbine generator. However, many of the new combined-cycle plants are packaged systems and because many older coal-fired plants were custom built, they do not always come in standard sizes or configurations. If such facilities are to be repowered, additional work is required to integrate the system components and this could be very costly.

The IGCC is a repowering option that required extensive gasification equipment to generate synthetic gas from coal in order to feed the gas turbines. IGCC unit installation could also result in significant reduction of Hg. IGCC plants offer the capability of removing the Hg from the compressed syngas prior to combustion where the gas volume treated is much less than the low pressure, post-combustion flow volume (Parsons, 2002). The predominant form of Hg in the IGCC syngas is elemental and removing prior to combustion is considered to be far more cost-effective than controlling emissions from the exhaust.

References:

EPA, 1998: U.S. Environmental Protection Agency, "Analyzing Electric Power Generation Under the Clean Air Act Amendments, Appendix 3," March 1998.

Parsons, 2002: Parsons Infrastructure and Technology Group, Inc., "The Cost of Mercury Removal in an IGCC Plant, Final Report," prepared for the U.S. Department of Energy, National Energy Technology Laboratory, September 2002.

Seitz, 1994: John Seitz, U.S. Environmental Protection Agency, Office of Air Quality Planning and

AT-A-GLANCE TABLE FOR UTILITY SOURCES

Standards, Memorandum: Subject: NO_x Reasonably Available Control Technologies for the Repowering of Utility Boilers, March, 1994.

AT-A-GLANCE TABLE FOR UTILITY SOURCES

Source Category: Utility Boilers - Coal-Fired

Control Measure Name: Fuel Switching - High-Sulfur Coal to Low-Sulfur Coal

Rule Name: Not Applicable

Pechan Measure Code: SUT-S

POD: H

Application: In terms of fuel composition, sulfur content is a major factor in determining the potential SO₂ emissions levels. SO₂ emissions can be reduced by switching from high-sulfur to low-sulfur coal. However, the emission reduction levels will depend on the types of coal that are being switched (DOE, 1997).

This control is applicable to electricity generating sources powered by pulverized dry-bottom and bituminous/subbituminous coal.

Affected SCC:

10100202 Electric Generation, Pulverized-Dry Bottom (Bituminous Coal)

10100203 Electric Generation, Bituminous/Subbituminous Coal, Cyclone Furnace (Bituminous)

10100212 Electric Generation, Pulverized Coal-Dry Bottom (Tangential) (Bituminous Coal)

10100217 Bituminous/Subbituminous Coal, Atm. Fluidized Bed Combustion-Bubbling (Bituminous)

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√	√					√*			

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: The control efficiency varies by pollutant: SO₂ (60%.); PM₁₀ (21.4%); PM_{2.5} (21.4%)

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs associated with switching from high-sulfur coal to low sulfur coal vary widely depending on the original and replacement coal types. Capital costs may include new storage and distribution systems as well as modifications to the combustion operations. Switching from bituminous to a subbituminous coal can also lead to an increase in the particulate matter emissions, requiring further investments on controls.

The costs detailed here are based on fuel switching and blending from high-sulfur content bituminous to low-sulfur bituminous and to subbituminous coal.

Cost Effectiveness: Cost effectiveness varies depending on the ranks of the old and new fuels and is estimated based on the emission factors. The cost effectiveness ranged from \$113 to \$167 per ton SO₂ reduced. The cost effectiveness value used in AirControlNET is \$140 per ton SO₂ reduced. All costs are in 1995 dollars.

Comments:

Status: Demonstrated

Last Reviewed: 2003

AT-A-GLANCE TABLE FOR UTILITY SOURCES

Additional Information:

Coal contains noncombustible minerals and mineral oxides that are collectively referred to as ash. In terms of fuel composition, ash content of fuel is the major factor in determining total suspended particle emissions (TSP). The higher the ash content, the higher the amount of TSP emitted from combustion. Fuel substitution can impact TSP emissions leading to their reduction. It should be noted that if the new coal has a significantly lower energy content there may be an increase in TSP emissions due to the higher amounts of coal needed to achieve the same energy output (DOE, 1994).

While effective in lowering SO₂ and PM emissions, the practice of switching to a low-sulfur content can lead to reduced collection efficiency of electrostatic precipitators which are the most common method of particulate controls for utility boilers. Lowering the flue gas sulfur content increases the fly ash resistivity and subsequently lowers the overall particulate matter collection efficiency at these post-combustion units. Lower particle collection efficiency in coal fired boilers leads to a lower mercury removal efficiency. Therefore this form of fuel switching, from high-sulfur to low-sulfur coal, is not a viable option for controlling mercury and will not be discussed in detail.

References:

DOE, 1994: U.S. Department of Energy, Energy Information Administration, Office of Coal, Nuclear, Electric and Alternate Fuels, "Electric Utility Phase I Acid Rain Compliance Strategies for the Clean Air Act Amendments of 1990," Washington, DC, March 1994.

DOE, 1997: U.S. Department of Energy, Energy Information Administration, Office of Coal, Nuclear, Electric and Alternate Fuels, "The effects of Title IV of the Clean Air Act Amendments of 1990 on Electric Utilities: An Update," DOE/EIA-0582(97), Washington, DC, March 1997.

AT-A-GLANCE TABLE FOR UTILITY SOURCES

Source Category: Utility Boilers - Coal-Fired

Control Measure Name: Coal Washing

Rule Name: Not Applicable

Pechan Measure Code: SUT-W

POD: H

Application: Coal washing (or coal cleaning) is a pre-combustion process that improves the quality of coal by removing impurities and increasing its heat content, thus reducing SO₂ emissions. Coal washing can also be effective in removing mercury (Hg) from the coal and the utility plants emissions.

This control is applicable to electricity generating sources powered by pulverized dry-bottom and bituminous/subbituminous coal.

Affected SCC:

10100202 Electric Generation, Pulverized-Dry Bottom (Bituminous Coal)

10100203 Electric Generation, Bituminous/Subbituminous Coal, Cyclone Furnace (Bituminous)

10100212 Electric Generation, Pulverized Coal-Dry Bottom (Tangential) (Bituminous Coal)

10100217 Bituminous/Subbituminous Coal, Atm. Fluidized Bed Combustion-Bubbling (Bituminous)

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√	√					√*			√

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: The control efficiency varies by pollutant: SO₂ (35%); PM (45%); Hg (21%)

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs associated with coal washing are usually included in the price of coal in terms of the added cost of the cleaned product over the original run-of-mine coal. Disposal of the liquid wastes formed during these processes can be difficult and/or expensive and are reflected in the operating and maintenance costs (ERG, 2000).

The cost of coal washing can vary significantly based on characteristics of the raw coal and the types of processes involved, as well as the plant capacity. The capital costs for coal washing facilities range from \$12 to \$16 per ton of coal. Operating costs range from \$3.17 to \$4.40 per ton for systems that feature high BTU recovery, high levels of ash rejection (40-50%) and 20 to 50% sulfur removal (SIU, 1997).

Cost Effectiveness: Cost effectiveness varies based on the characteristics of the raw coal, washing processes and plant capacity from \$70 to \$563 per ton SO₂ reduced. The average cost used in AirControlNET is \$320 per ton SO₂ reduced. All costs are in 1997 dollars.

Comments:

Status: Demonstrated

Last Reviewed: 2003

AT-A-GLANCE TABLE FOR UTILITY SOURCES

Additional Information:

Coal contains noncombustible minerals and mineral oxides that are collectively referred to as ash. Coal washing is a pre-combustion process which is used to remove ash and sulfur from the coal. During this process rock, clay and other minerals can be separated from the coal in a liquid medium.

Coal washing is a process that is applied before delivery to the utility plant. In some cases, however, coal is passed through a drying step at the power plant before loading into the boiler.

Coal washing can also be an effective method for removing Hg. Estimated overall reductions at national levels were reported to be 21% (EPA, 1997).

Coal washing can separate minerals from coal through the difference in specific gravities of the constituents or by surface-based floatation. Two types of coal washing methods can be performed on intermediate and coarse coal:

1. Gravity concentration method: Technologies that use this method include jigs, cyclones, shaking tables and Reichert cones. A significant portion of coal preparation plants use jigs to separate coal from non-coal material. The majority of jigs process wet coal, but some pneumatic jigs are also used. Like jigs, the shaking tables, cyclones and Reichert cones rely on water flow and motion of the equipment to separate more dense impurities from the lighter coal (EPA, 2000).

2. Dense medium separation method: This process usually takes place in large open tanks, with the pulverized magnetite (Fe_3O_4) in water used as the preferred medium for separation. The density of the medium is adjusted to lie between the dense inorganic matter and the less dense organic combustible fraction of coal. As a result, the inorganic material sinks to the bottom of the tank and the organic coal floats to the top where it is skimmed from the tank.

Fine coal cleaning involves chemical conditioning of the coal followed by flotation to recover clean coal. Depending on the characteristics of the coal, some mines may perform fine coal conditioning using lime, sodium carbonate, sodium hydroxide or sulfuric acid. Conditioning is used to adjust pH, to facilitate the flotation process (EPA, 2000).

References:

EPA, 1997: U.S. Environmental Protection Agency, "Mercury Study Report to Congress, Volume III: Fate and Transport of Mercury in the Environment," EPA/452/R-97-005, December 1997.

EPA, 2000: U.S. Environmental Protection Agency, Office of Pollution Prevention and Toxics, "EPCRA Section 313 Industry Guidance, Coal Mining Facilities," EPA/7450/B-00-003, Washington, DC, February 2000.

ERG, 2000: Eastern Research Group, Inc., "Point Sources Committee Emission Inventory Improvement Program: How to Incorporate the Effects of Air Pollution Control Device Efficiencies and Malfunctions into Emission Inventory Estimates," prepared for U.S. Environmental Protection Agency, July 2000.

SIU, 1997: Southern Illinois University, Office of Coal Development and Marketing, "Coal Technology Profiles," Carbondale, IL, June 1997.

AT-A-GLANCE TABLE FOR UTILITY SOURCES

Source Category: Utility Boilers - High Sulfur Content

Control Measure Name: Flue Gas Desulfurization (Wet Scrubber Type)

Rule Name: Not Applicable

Pechan Measure Code: SUT-H

POD: H

Application: This control is based on the addition of wet scrubber type flue gas desulfurization add-on controls to reduce SO₂ emissions. In wet systems, a liquid sorbent is sprayed into the flue gas in an absorber vessel, removing PM from the gas flow. Limestone and lime-based sorbents are most frequently used in scrubbers in the United States (Pechan, 1997).

This control is applicable to electricity generating sources powered by pulverized dry-bottom and bituminous/subbituminous coal.

Affected SCC:

10100202 Electric Generation, Pulverized-Dry Bottom (Bituminous Coal)

10100203 Electric Generation, Bituminous/Subbituminous Coal, Cyclone Furnace (Bituminous)

10100212 Electric Generation, Pulverized Coal-Dry Bottom (Tangential) (Bituminous Coal)

10100217 Bituminous/Subbituminous Coal, Atm. Fluidized Bed Combustion-Bubbling (Bituminous)

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
							√*			√

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 90% from uncontrolled for SO₂; 64% from uncontrolled for Hg

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Control cost equations used for estimating the costs of applying scrubbers were developed for electric utility boilers. The cost equations used in this analysis are based on cost equations developed to scale costs to smaller or larger boilers than the model plant (EPA, 1998)). Model plants were considered to have boiler design capacities of 500 MW. Several simplifying assumptions were made in developing the costing parameters used for this analysis. A capacity utilization factor of 65 percent was assumed, as well as a 7-percent discount rate and 15-year lifetime for the scrubber. A control efficiency of 90 percent was assumed for scrubbers on all utility boiler fuel types.

The fuel sulfur content level for these equations is 3% sulfur.

Capital Costs (CC):

Nameplate Capacity: netdc [=] MW

Total Capital Costs: TCC = \$166 per kW

Scaling Factor: SF = (sfn / netdc)^{sfe} = (500 / MW)^{0.6}

CC (for netdc < 500) = TCC * netdc * 1000 * SF

CC (for netdc > 500) = TCC * netdc * 1000

AT-A-GLANCE TABLE FOR UTILITY SOURCES

Operating & Maintenance (O&M):

Fixed O&M: omf = \$6.00 per kW per year

Variable O&M: omv = \$6.30 mills per kW-hr

Capacity Factor: capfac = 0.65

$$\text{O\&M} = (\text{omf} * \text{netdc} * 1000) + (\text{omv} * \text{netdc} * 1000 * \text{capfac} * 8760 / 1000)$$

Equipment Life in Years = Equiplife

Interest Rate = i

$$\text{Capital Recovery Factor: CRF} = [i (1 + i)^{\text{Equiplife}}] / [(1 + i)^{\text{Equiplife}} - 1]$$

$$\text{Total Cost} = (\text{CRF} * \text{CC}) + \text{O\&M}$$

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's CUE Cost (EPA, 2000) program. O&M costs were calculated for the model plant and the percentage of the total O&M cost was then calculated for each O&M cost component. A credit for the sale of by-product was subtracted from the disposal costs. A capacity factor of 65% was assumed. The following assumptions apply to the cost of utilities and disposal:

Calcium Carbonate	15	\$/ton
Dibasic acid	430	\$/ton
Disposal by gypsum stacking	6	\$/ton
Disposal by landfill	30	\$/ton
Credit for by-product	2	\$/ton
Steam	3.5	\$/1000 lb
Electrical energy	25	mills/kWh

Note: All costs are in 1990 dollars.

Cost Effectiveness: Cost effectiveness varies depending on the nameplate capacity (in MW). The cost effectiveness depends on the following factors: total capital costs of \$166 per kW; fixed O&M costs of \$6.00 per kW per year; and variable O&M costs of \$6.30 mills per kW-hr (1990\$).

Comments:

Status: Demonstrated	Last Reviewed: 2001
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Additional Information:

In wet systems, a liquid sorbent is sprayed into the flue gas in an absorber vessel. Limestone and lime-based reagents are most frequently used in scrubbers in the United States (EPA, 2002a).

Studies have shown that Wet FGD can also be effective in controlling mercury emissions. The ionic mercury compounds in coal flue gases are water-soluble and can be captured by WFGD scrubbers.

In Wet FGD, the soluble gaseous Hg is mixed with the water-based scrubbing liquid and then removed from the flue stream with the disposed scrubbing solution. Wet Flue Gas Desulfurization scrubbers use a caustic slurry, typically water and limestone or water and lime as SO₂ scrubbing solutions.

AT-A-GLANCE TABLE FOR UTILITY SOURCES

The level of mercury capture in Wet FGD systems depends on the relative level of Hg^{2+} present in the flue gas that enters the system. The gaseous Hg^0 is insoluble in water and does not dissolve in such slurries. The majority of Hg^{2+} species in the flue gas are soluble in water. After they are dissolved in the FGD solution, these mercury compounds are believed to react with dissolved sulfides from the flue gas, such as H_2S , to form mercuric sulfide (HgS), which precipitates from the liquid solution as sludge. The level of Hg^{2+} that enters the Wet FGD system depends on the flue gas as well as the upstream control system (e.g., a FF and SCR, used for PM and NO_x control, respectively oxidizes the elemental mercury). A PM control device always precedes a wet Wet FGD scrubber. Four types of PM control devices are commonly used upstream of the Wet FGD systems: FFs, CS-ESPs, HS-ESPs, and PM scrubbers (PS). In systems with a FF upstream of the Wet FGD system, an increase in mercury reduction is observed across the Wet FGD system due to the oxidization of elemental mercury that occurs on the fabric filter cake. Units equipped with FF+WFGD achieve the highest Hg reduction followed by units with CS-ESP, HS-ESP, and PS. Units with HS-ESPs operate at temperatures where the oxidization and capture of Hg is limited; therefore, a lower mercury reduction across the system is achieved (Massachusetts, 2002).

Mercury control efficiencies of existing post-combustion controls used for coal-fired electric utility boilers were examined based on a series of tests that were conducted as part of a research and development study by the National Risk Management Research Laboratory for EPA (EPA, 2002b). Table 3 shows the overall mercury control efficiencies for the SO_2 co-controls. Note: the control efficiencies are provided for a combined unit operations (WFGD plus a PM control device).

References:

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Research and Development, Control Of Mercury Emissions From Coal-Fired Electric Utility Boilers: Interim Report Including Errata Dated 3-21-02," EPA-600/R-01-109, April 2002.

EPA, 2000: U.S. Environmental Protection Agency, Office of Research and Development, "Coal Utility Environmental Cost (CUECost) Version 3.0" [computer program], February 2000.

EPA, 1998: U.S. Environmental Protection Agency, "Analyzing Electric Power Generation Under the Clean Air Act Amendments, Appendix 3," March 1998.

EPA, 1998: U.S. Environmental Protection Agency, "Analyzing Electric Power Generation Under the Clean Air Act Amendments, Appendix 3," March 1998.

Massachusetts, 2002: Commonwealth of Massachusetts, Department of Environmental Protection, Executive Office of Environmental Affairs, Division of Planning and Evaluation, Bureau of Waste Prevention, "Evaluation Of The Technological and Economic Feasibility of Controlling and Eliminating Mercury Emissions from the Combustion of Solid Fossil Fuel, Pursuant To 310 CMR 7.29 - Emissions Standards For Power Plants," Downloaded from <http://www.state.ma.us/dep/bwp/daqc/daqcpubs.htm#other>, December 2002.

Pechan, 1997: E.H. Pechan & Associates: "Additional Control Measure Evaluation for the Integrated Implementation of the Ozone and Particulate Matter National Ambient Air Quality Standards, and Regional Haze Program," prepared for U.S. Environmental Protection Agency, July 1997.

AT-A-GLANCE TABLE FOR UTILITY SOURCES

Source Category: Utility Boilers - Medium Sulfur Content

Control Measure Name: Flue Gas Desulfurization (Wet Scrubber Type)

Rule Name: Not Applicable

Pechan Measure Code: SUT-M

POD: M

Application: This control is based on the addition of wet scrubber type flue gas desulfurization add-on controls to reduce SO₂ emissions. In wet systems, a liquid sorbent is sprayed into the flue gas in an absorber vessel, removing PM from the gas flow. Limestone and lime-based sorbents are most frequently used in scrubbers in the United States (Pechan, 1997).

This control is applicable to electricity generating sources powered by pulverized dry-bottom, bituminous/subbituminous coal, and natural gas.

Affected SCC:

10100202 Electric Generation, Pulverized-Dry Bottom (Bituminous Coal)
10100203 Electric Generation, Bituminous/Subbituminous Coal, Cyclone Furnace (Bituminous)
10100212 Electric Generation, Pulverized Coal-Dry Bottom (Tangential) (Bituminous Coal)
10100217 Bituminous/Subbituminous Coal, Atm. Fluidized Bed Combustion-Bubbling (Bituminous)
10100601 Electric Generation, Natural Gas, Boilers > 100 Million Btu/hr except Tangential
10100604 Electric Generation, Natural Gas, Tangentially Fired Units

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
							√*			√

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 90% from uncontrolled for SO₂; 64% from uncontrolled for Hg

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Control cost equations used for estimating the costs of applying scrubbers were developed for electric utility boilers. The cost equations used in this analysis are based on cost equations developed to scale costs to smaller or larger boilers than the model plant (EPA, 1998). Model plants were considered to have boiler design capacities of 500 MW. Several simplifying assumptions were made in developing the costing parameters used for this analysis. A capacity utilization factor of 65 percent was assumed, as well as a 7-percent discount rate and 15-year lifetime for the scrubber. A control efficiency of 90 percent was assumed for scrubbers on all utility boiler fuel types.

The fuel sulfur content level for these equations is 2% sulfur.

Capital Costs (CC):

Nameplate Capacity: netdc [=] MW

Total Capital Costs: TCC = \$149 per kW

Scaling Factor: SF = (sfn / netdc)^{sfe} = (500 / MW)^{0.6}

AT-A-GLANCE TABLE FOR UTILITY SOURCES

CC (for netdc < 500) = TCC * netdc * 1000 * SF
CC (for netdc > 500) = TCC * netdc * 1000

Operating & Maintenance (O&M):

Fixed O&M: omf = \$5.40 per kW per year
Variable O&M: omv = \$0.83 mills per kW-hr
Capacity Factor: capfac = 0.65

O&M = (omf * netdc * 1000) + (omv * netdc * 1000 * capfac * 8760 / 1000)

Equipment Life in Years = Equiplife

Interest Rate = i

Capital Recovery Factor: CRF = [i (1 + i) ^ Equiplife] / [((1 + i) ^ Equiplife) - 1]

Total Cost = (CRF * CC) + O&M

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's CUE Cost (EPA, 2000) program. O&M costs were calculated for the model plant and the percentage of the total O&M cost was then calculated for each O&M cost component. A credit for the sale of by-product was subtracted from the disposal costs. A capacity factor of 65% was assumed. The following assumptions apply to the cost of utilities and disposal:

Calcium Carbonate	15	\$/ton
Dibasic acid	430	\$/ton
Disposal by gypsum stacking	6	\$/ton
Disposal by landfill	30	\$/ton
Credit for by-product	2	\$/ton
Steam	3.5	\$/1000 lb
Electrical energy	25	mills/kWh

Note: All costs are in 1990 dollars.

Cost Effectiveness: Cost effectiveness varies depending on the nameplate capacity (in MW). The cost effectiveness depends on the following factors: total capital costs of \$149 per kW; fixed O&M costs of \$5.40 per kW per year; and variable O&M costs of \$0.83 mills per kW-hr (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

In wet systems, a liquid sorbent is sprayed into the flue gas in an absorber vessel. Limestone and lime-based reagents are most frequently used in scrubbers in the United States (EPA, 2002a).

Studies have shown that Wet FGD can also be effective in controlling mercury emissions. The ionic mercury compounds in coal flue gases are water-soluble and can be captured by WFGD scrubbers.

In Wet FGD, the soluble gaseous Hg is mixed with the water-based scrubbing liquid and then removed from the flue stream with the disposed scrubbing solution. Wet Flue Gas Desulfurization scrubbers use a caustic slurry, typically water and limestone or water and lime as SO₂ scrubbing

AT-A-GLANCE TABLE FOR UTILITY SOURCES

solutions.

The level of mercury capture in Wet FGD systems depends on the relative level of Hg^{2+} present in the flue gas that enters the system. The gaseous Hg_0 is insoluble in water and does not dissolve in such slurries. The majority of Hg^{2+} species in the flue gas are soluble in water. After they are dissolved in the FGD solution, these mercury compounds are believed to react with dissolved sulfides from the flue gas, such as H_2S , to form mercuric sulfide (HgS), which precipitates from the liquid solution as sludge. The level of Hg^{2+} that enters the Wet FGD system depends on the flue gas as well as the upstream control system (e.g., a FF and SCR, used for PM and NO_x control, respectively oxidizes the elemental mercury). A PM control device always precedes a wet Wet FGD scrubber. Four types of PM control devices are commonly used upstream of the Wet FGD systems: FFs, CS-ESPs, HS-ESPs, and PM scrubbers (PS). In systems with a FF upstream of the Wet FGD system, an increase in mercury reduction is observed across the Wet FGD system due to the oxidization of elemental mercury that occurs on the fabric filter cake. Units equipped with FF+WFGD achieve the highest Hg reduction followed by units with CS-ESP, HS-ESP, and PS. Units with HS-ESPs operate at temperatures where the oxidization and capture of Hg is limited; therefore, a lower mercury reduction across the system is achieved (Massachusetts, 2002).

Mercury control efficiencies of existing post-combustion controls used for coal-fired electric utility boilers were examined based on a series of tests that were conducted as part of a research and development study by the National Risk Management Research Laboratory for EPA (EPA, 2002b). Table 3 shows the overall mercury control efficiencies for the SO_2 co-controls. Note: the control efficiencies are provided for a combined unit operations (WFGD plus a PM control device).

References:

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Research and Development, Control Of Mercury Emissions From Coal-Fired Electric Utility Boilers: Interim Report Including Errata Dated 3-21-02," EPA-600/R-01-109, April 2002.

EPA, 2000: U.S. Environmental Protection Agency, Office of Research and Development, "Coal Utility Environmental Cost (CUECost) Version 3.0" [computer program], February 2000.

EPA, 1998: U.S. Environmental Protection Agency, "Analyzing Electric Power Generation Under the Clean Air Act Amendments, Appendix 3," March 1998.

Massachusetts, 2002: Commonwealth of Massachusetts, Department of Environmental Protection, Executive Office of Environmental Affairs, Division of Planning and Evaluation, Bureau of Waste Prevention, "Evaluation Of The Technological and Economic Feasibility of Controlling and Eliminating Mercury Emissions from the Combustion of Solid Fossil Fuel, Pursuant To 310 CMR 7.29 - Emissions Standards For Power Plants," Downloaded from <http://www.state.ma.us/dep/bwp/daqc/daqcpubs.htm#other>, December 2002.

Pechan, 1997: E.H. Pechan & Associates: "Additional Control Measure Evaluation for the Integrated Implementation of the Ozone and Particulate Matter National Ambient Air Quality Standards, and Regional Haze Program," prepared for U.S. Environmental Protection Agency, July 1997.

AT-A-GLANCE TABLE FOR UTILITY SOURCES

Source Category: Utility Boilers - Very High Sulfur Content

Control Measure Name: Flue Gas Desulfurization (Wet Scrubber Type)

Rule Name: Not Applicable

Pechan Measure Code: SUT-VH

POD: VH

Application: This control is based on the addition of wet scrubber type flue gas desulfurization add-on controls to reduce SO₂ emissions. In wet systems, a liquid sorbent is sprayed into the flue gas in an absorber vessel, removing PM from the gas flow. Limestone and lime-based sorbents are most frequently used in scrubbers in the United States (Pechan, 1997).

This control is applicable to electricity generating sources powered by pulverized dry-bottom and bituminous/subbituminous coal.

Affected SCC:

10100202 Electric Generation, Pulverized-Dry Bottom (Bituminous Coal)

10100203 Electric Generation, Bituminous/Subbituminous Coal, Cyclone Furnace (Bituminous)

10100212 Electric Generation, Pulverized Coal-Dry Bottom (Tangential) (Bituminous Coal)

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
							√*			√

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 90% from uncontrolled

Equipment Life: 15 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Control cost equations used for estimating the costs of applying scrubbers were developed for electric utility boilers. The cost equations used in this analysis are based on cost equations developed to scale costs to smaller or larger boilers than the model plant (EPA, 1998). Model plants were considered to have boiler design capacities of 500 MW. Several simplifying assumptions were made in developing the costing parameters used for this analysis. A capacity utilization factor of 65 percent was assumed, as well as a 7-percent discount rate and 15-year lifetime for the scrubber. A control efficiency of 90 percent was assumed for scrubbers on all utility boiler fuel types.

The fuel sulfur content level for these equations is 4% sulfur.

Capital Costs (CC):

Nameplate Capacity: netdc [=] MW

Total Capital Costs: TCC = \$174 per kW

Scaling Factor: SF = (sfn / netdc)^{sfe} = (500 / MW)^{0.6}

CC (for netdc < 500) = TCC * netdc * 1000 * SF

CC (for netdc > 500) = TCC * netdc * 1000

AT-A-GLANCE TABLE FOR UTILITY SOURCES

Operating & Maintenance (O&M):

Fixed O&M: omf = \$6.30 per kW per year

Variable O&M: omv = \$1.80 millions per kW-hr

Capacity Factor: capfac = 0.65

$$\text{O\&M} = (\text{omf} * \text{netdc} * 1000) + (\text{omv} * \text{netdc} * 1000 * \text{capfac} * 8760 / 1000)$$

Equipment Life in Years = Equiplife

Interest Rate = i

$$\text{Capital Recovery Factor: CRF} = [i (1 + i)^{\text{Equiplife}}] / [(1 + i)^{\text{Equiplife}} - 1]$$

$$\text{Total Cost} = (\text{CRF} * \text{CC}) + \text{O\&M}$$

O&M Cost Components: The percentages of each O&M cost component were developed using EPA's CUE Cost (EPA, 2000) program. O&M costs were calculated for the model plant and the percentage of the total O&M cost was then calculated for each O&M cost component. A credit for the sale of by-product was subtracted from the disposal costs. A capacity factor of 65% was assumed. The following assumptions apply to the cost of utilities and disposal:

Calcium Carbonate	15	\$/ton
Dibasic acid	430	\$/ton
Disposal by gypsum stacking	6	\$/ton
Disposal by landfill	30	\$/ton
Credit for by-product	2	\$/ton
Steam	3.5	\$/1000 lb
Electrical energy	25	mills/kWh

Note: All costs are in 1990 dollars.

Cost Effectiveness: Cost effectiveness varies depending on the nameplate capacity (in MW). The cost effectiveness depends on the following factors: total capital costs of \$174 per kW; fixed O&M costs of \$6.30 per kW per year; and variable O&M costs of \$1.80 mills per kW-hr (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 2001

Additional Information:

In wet systems, a liquid sorbent is sprayed into the flue gas in an absorber vessel. Limestone and lime-based reagents are most frequently used in scrubbers in the United States (EPA, 2002).

References:

EPA, 2000: U.S. Environmental Protection Agency, Office of Research and Development, "Coal Utility Environmental Cost (CUECost) Version 3.0" [computer program], February 2000.

EPA, 1998: U.S. Environmental Protection Agency, "Analyzing Electric Power Generation Under the Clean Air Act Amendments, Appendix 3," March 1998.

EPA, 1998: U.S. Environmental Protection Agency, "Analyzing Electric Power Generation Under the Clean Air Act Amendments, Appendix 3," March 1998.

AT-A-GLANCE TABLE FOR UTILITY SOURCES

Pechan, 1997: E.H. Pechan & Associates: "Additional Control Measure Evaluation for the Integrated Implementation of the Ozone and Particulate Matter National Ambient Air Quality Standards, and Regional Haze Program," prepared for U.S. Environmental Protection Agency, July 1997.

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Adhesives - Industrial

Control Measure Name: SCAQMD Rule 1168

Rule Name: South Coast Air Quality Management District Rule 1168 - Adhesive and Sealant Applications

Pechan Measure Code: V22601

POD: 226

Application: The SCAQMD rule 1168 sets limits for adhesive and sealant VOC content. The rule has been amended several times to require the use of waterborne, hot melt and other types of adhesives (SCAQMD, 1996).

Emissions associated with the use of industrial adhesives are classified under SCC 2440020000.

Affected SCC:

2401020000 Wood Furniture: SIC 25, Total: All Solvent Types

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
						√*				

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 73% from uncontrolled

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The cost estimates are based on the SCAQMD Rule 1168 VOC limits. No cost estimates were given in this document; however, the Bay Area adopted the same limits as part of its 1991 plan. In the 1991 plan a cost estimate range was given (BAAQMD, 1991). An estimate in the upper end of the range given in the 1991 Bay Area Clean Air Plan, is assumed for this analysis.

Cost Effectiveness: The total cost effectiveness used in AirControlNET is \$2,202 per ton VOC reduction (1990\$), an estimate in the upper end of the documented range.

Comments:

Status: Demonstrated

Last Reviewed: 1997

Additional Information:

This control measure is based on the SCAQMD's original Rule 1168 - Control of VOC Emissions from Adhesive Application, and further reductions from the SCAQMD's amendments to its rule. At the time of adoption, the SCAQMD's Rule 1168 was considered a technology-forcing regulation because it assumed the future availability of low-VOC adhesives. The Bay Area AQMD adopted the same content limits as specified in the SCAQMD's original Rule 1168.

References:

BAAQMD, 1991: Bay Area Air Quality Management District, "Bay Area '91 Clean Air Plan: Volume III. Appendix G - Stationary Source Control Measure Descriptions," October 1991.

AT-A-GLANCE TABLE FOR AREA SOURCES

Pechan , 1997: E.H. Pechan & Associates: "Additional Control Measure Evaluation for the Integrated Implementation of the Ozone and Particulate Matter National Ambient Air Quality Standards, and Regional Haze Program," prepared for U.S. Environmental Protection Agency, July 1997.

SCAQMD, 1996: South Coast Air Quality Management District, "1997 Air Quality Management Plan - Appendix IV-A. Stationary and Mobile Source Control Measures," August 1996.

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Aircraft Surface Coating

Control Measure Name: MACT Standard

Rule Name: Maximum Achievable Control Technology for Aircraft Surface Coating

Pechan Measure Code: V25001

POD: 250

Application: This control measure represents the Aerospace Manufacturing NESHAP, promulgated in September 1995. Options for compliance include work practice standards for cleaning operations, carbon adsorber use, no HAP strippers, and control of HAP from spray coating and blast depainting operations.

The rule affects over 2,800 major source facilities that produce or repair aerospace vehicles or vehicle parts, such as airplanes, helicopters and missiles. (Pechan, 1998)

Affected SCC:

2401075000 Aircraft: SIC 372, Total: All Solvent Types

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
						√*				

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 60% from uncontrolled

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The nationwide annual cost of the regulation across all affected sources, including monitoring, record keeping, and reporting, is estimated by EPA to be approximately \$20 million.

Cost Effectiveness: A cost effectiveness of \$165 per ton of VOC reduced (1990\$) is used, based on EPA's assumption that 5 percent of sources will choose to incur abatement costs, and the remaining sources will opt for pollution prevention measures (60FR45948, 1995). Furthermore, EPA estimates the aircraft surface coating MACT will provide a 60 percent reduction.

Comments:

Status: Demonstrated

Last Reviewed: 1998

Additional Information:

The rule has an emissions averaging provision that will allow facilities additional compliance flexibility.

References:

60FR45948, 1995: Federal Register, "National Emission Standards for Hazardous Air Pollutants for Source Categories/Aerospace Manufacturing NESHAP, Final Rule," Vol. 60, No. 170, September 1995.

Pechan, 1998: E. H. Pechan & Associates Inc., "Emission Projections for the Clean Air Act Section 812 Prospective Analysis," June 1998.

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Architectural Coatings

Control Measure Name: AIM Coating Federal Rule

Rule Name: Architectural and Industrial Maintenance Coatings Federal Rule

Pechan Measure Code: V22001

POD: 220

Application: This federal rule provides uniformity over the state-level content limits that AIM coating manufacturers must meet. The rule sets maximum allowable VOC content limits for 55 different categories of AIM coatings, and affects the manufacturers and importers of the coating products. VOC content limits defined in the national rule took effect on September 11, 1999. Manufacturers of FIFRA - regulated coatings had until March 10, 2000 to comply.

Sixty-four percent of the products included in the 1990 industry survey meet the VOC content limits in this rule and, therefore, there will be no costs to reformulate these products. The manufacturer of a product that does not meet the VOC content limits will be required to reformulate the product if it will continue to be marketed, unless the manufacturer chooses to use an alternative compliance option such as the exceedance fee or tonnage exemption provision.

In AirControlNET, this control measure only affects architectural coatings.

Affected SCC:

2401001000 Architectural Coatings, Total: All Solvent Types

2401001999 Architectural Coatings, Solvents: NEC

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
						√*				

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 20% from uncontrolled

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The cost estimates are based upon information provided to EPA by industry representatives during the regulatory negotiation process. Industry representatives estimated the level of effort required by a representative firm to research and develop a new prototype coating to be 2.5 scientist-years over a 3-year time period. EPA calculated an annualized cost of \$17,772 per reformulation (1991 dollars) based on an assumed cost of \$100,000 per scientist-year as amortized over an assumed repopulation cycle of 2.5 years.

The estimated average cost to reformulate a product was \$87,000. The total estimated national cost of the AIM Coating Federal rule is 25.6 million per year (1991 dollars).

Cost Effectiveness: EPA estimated emission reductions of 106,000 tons of VOC per year so that the cost effectiveness is computed as \$228 per ton VOC reduction (1990\$)..

Comments: The EPA did not account for potential cost differences for reformulating coatings to

AT-A-GLANCE TABLE FOR AREA SOURCES

various content limits. Instead, EPA assumed that a reformulation has a certain cost to manufacturers regardless of the target content limit, or the anticipated VOC reduction (Ducey, 1997).

Status: Demonstrated

Last Reviewed: 1998

Additional Information:

In its analysis of the proposed federal rule, EPA assumed that the cost of product reformulation would bring the VOC content limit for each noncompliant coating down to the level of the standards. The EPA, however, noted the likelihood that some manufacturers will likely reduce the VOC content of their coatings to levels significantly below the limits in the rule (EPA, 1996). The at-the-limit assumption, therefore, likely results in emission reductions being understated. In its cost analysis, insufficient data were available for EPA to distinguish reformulation costs between different coating types (i.e., the reformulation cost for flat paints is equal to the reformulation cost for all other affected paint types). The EPA noted the likelihood of reformulation costs varying from product to product (EPA, 1995).

References:

Ducey, 1997: E. Ducey, U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, personal communication with D. Crocker, E.H. Pechan & Associates, Inc., February 13, 1997.

EPA, 1995: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Economic Impact and Regulatory Flexibility Analysis of the Proposed Architectural Coatings Federal Rule," Research Triangle Park, NC, March 1995.

EPA, 1996: U.S. Environmental Protection Agency, Emission Standards Division, Office of Air and Radiation, "Architectural Coatings - Background for Proposed Standards, Draft Report," EPA-453/R-95-009a, March 1996.

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Architectural Coatings

Control Measure Name: South Coast Phase I

Rule Name: South Coast AQMD Rule 1113 - Architectural Coatings

Pechan Measure Code: V22002

POD: 220

Application: The Phase I rule is an amendment to SCAQMD's existing architectural coatings rule that establishes more stringent VOC content limits for flat, multi-color, traffic, and lacquer coatings. These VOC limits in the SCAQMD for multi-color, traffic, and lacquer coatings took effect on January 1, 1998, while the Phase I limits for flat coating took effect on January 1, 2001.

Reductions in VOC emissions from these coatings are achieved through the use of product reformulation and product substitution.

In AirControlNET this measure only affects architectural coatings VOC emissions.

Affected SCC:

2401001000 Architectural Coatings, Total: All Solvent Types

2401001999 Architectural Coatings, Solvents: NEC

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
						√*				

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 34% from uncontrolled

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: For the Phase I amendment, a SCAQMD report documents cost per gallon, total annual cost, emission reduction and cost-effectiveness values for each of the four regulated coating types (SCAQMD, 1996).

The SCAQMD estimated that manufacturers would use an acetone formulation with an associated cost of \$2 per gallon to meet the proposed 550 grams per liter (g/L) VOC limit for lacquers. For flats, South Coast estimated a zero cost for complying with the near-term 100 g/L limit since most flats sold in California are already in compliance with this limit. For traffic and multi-color coatings, the SCAQMD estimated that a cost savings was likely to be associated with reformulation due to a decrease in the cost of input materials. (The estimated magnitude of the savings is not documented in the SCAQMD report.)

Costs were estimated by multiplying the cost per gallon data to total gallons sold. The resulting weighted average cost effectiveness value was converted to 1990 dollars using the 1995:1990 producer price index for Standard Industrial Classification (SIC) code 2851 (Paints and Allied Products).

Because capital cost information was not available, capital costs were not estimated for this analysis.

AT-A-GLANCE TABLE FOR AREA SOURCES

Cost Effectiveness: Calculated cost-effectiveness values range from \$3,300 to \$4,600 per ton depending on the specified limit and coating type. The cost effectiveness range is attributable to the wide diversity of coatings.

AirControlNET uses a cost effectiveness of \$1,443 per ton VOC reduction based on a weighted average of national sales data by coating type (EPA, 1996) (1990\$).

Comments:

Status: Demonstrated	Last Reviewed: 1999
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Additional Information:

References:

CARB, 1989: California Air Resources Board, Stationary Source Division, "ARB-CAPCOA Suggested Control Measure for Architectural Coatings, Technical Support Document," July 1989.

EPA, 1996: U.S. Environmental Protection Agency, Emission Standards Division, Office of Air and Radiation, "Architectural Coatings - Background for Proposed Standards, Draft Report," EPA-453/R-95-009a, March 1996.

SCAQMD, 1996: South Coast Air Quality Management District, "Proposed Modifications to the Appendices of the Draft 1997 Air Quality Management Plan," October 1996.

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Architectural Coatings

Control Measure Name: South Coast Phase II

Rule Name: South Coast AQMD Rule 1113 - Architectural Coatings

Pechan Measure Code: V22003

POD: 220

Application: Phase II represents an effort to lower the VOC content limits for non-flat industrial maintenance primers and topcoats, sealers, undercoaters, and quick-dry enamels. The rule requires manufacturers of the coatings sold in the SCAQMD to meet the VOC limit requirements provided in the rule between 2002 and 2006.

Reductions in VOC emissions from these coatings are achieved through the use of product reformulation and product substitution.

In AirControlNET this measure only affects architectural coatings VOC emissions.

Affected SCC:

2401001000 Architectural Coatings, Total: All Solvent Types

2401001999 Architectural Coatings, Solvents: NEC

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
						√*				

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 47% from uncontrolled

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: For the Phase II amendments, the SCAQMD completed a socioeconomic impact assessment (SCAQMD, 1999). SCAQMD assumed a 10 percent price increase per gallon for compliant coatings meeting Phase II and estimated the cost based on the number of gallons produced. Costs vary significantly among individual coatings categories.

Because capital cost information was not available, capital costs were not estimated for this analysis.

Cost Effectiveness: AirControlNET uses a cost effectiveness of \$4,017 per ton VOC reduction (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 1996

Additional Information:

The South Coast notes that the process of collecting reformulation cost data for these categories is very complex due to the resin technology used in lower-VOC, high-performance industrial maintenance coatings (silicon-based resins, or polyurethanes) and the number of resin systems involved (Berry, 1997).

AT-A-GLANCE TABLE FOR AREA SOURCES

References:

Berry, 1997: N. Berry, South Coast Air Quality Management District, personal communication with D. Crocker, E.H. Pechan & Associates, Inc., March 4, 1997.

SCAQMD, 1999: South Coast Air Quality Management District, "Addendum to Staff Report: Final Socioeconomic Impact Assessment, Proposed Amendments to Rule 1113," May 1999.

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Architectural Coatings

Control Measure Name: South Coast Phase III

Rule Name: South Coast AQMD Rule 1113 - Architectural Coatings

Pechan Measure Code: V22004

POD: 220

Application: Phase III applies to additional consumer products that are not affected by Phase I or II. The rule requires manufacturers to limit VOC content of the specified coatings sold in the SCAQMD using a phased-in approach specifying compliance dates that depend on the coating type. Compliance dates range from 1/1/03 to 7/1/08.

Reductions in VOC emissions from these coatings are achieved through the use of product reformulation and product substitution.

The measure only applies to VOC emissions from architectural coatings in AirControlNET.

Affected SCC:

2401001000 Architectural Coatings, Total: All Solvent Types

2401001999 Architectural Coatings, Solvents: NEC

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
						√*				

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 73% from uncontrolled

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: SCAQMD has not yet estimated the costs for implementing the Phase III limits. As an estimate, Pechan uses the highest incremental cost effectiveness estimate for any individual product for the Phase II amendments of \$26,000 per ton (1998 dollars). This value is about double the average of Phase II products. This cost estimate is highly uncertain as no specific cost data are available (Pechan, 1999).

Because capital cost information was not available, capital costs were not estimated for this analysis.

Cost Effectiveness: AirControlNET uses an overall cost effectiveness of \$10,059 per ton VOC reduction (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 1996

Additional Information:

The Phase III controls apply to additional consumer products that are not affected by the near-term measures. These measures, which are expected to take effect between 2003 and 2008, are expected to result in an additional 26 percent VOC reduction from Phase II rules.

AT-A-GLANCE TABLE FOR AREA SOURCES

Pechan documentation indicates that CARB is currently funding a study to examine zero-polluting stains, waterproofing sealers, and clear wood finishes which will be used to comply with the third phase emission reductions.

References:

Pechan, 1999: E.H. Pechan & Associates, Inc., "Control Measure Evaluations: The Control Measure Data Base For the National Emission Trends Inventory (AirControlNET) – Draft Report," prepared for the U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, September 1999.

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Architectural Coatings

Control Measure Name: OTC AIM Coating Rule

Rule Name: OTC AIM Coating Rule

Pechan Measure Code: V24606

POD: 220

Application: This control requires manufacturers to reformulate coatings to meet specified VOC contents limits, which are specified in grams per liter. The VOC content limits contained in the AIM OTC Model Rule are based on the Suggested Control Measure (SCM) adopted by ARB, and the State and Territorial Air Pollution Program Administrators/Association of Local Air Pollution Control Officials (STAPPA/ALAPCO) model rule for AIM Coatings.

Affected SCC:

2401001000: Solvent Utilization: Surface Coating: Architectural Coatings: Total: All Solvent Types

2401001999: Solvent Utilization: Surface Coating: Architectural Coatings: Solvents: NEC

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
						√*				

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 55% from uncontrolled

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: A cost \$6,628 per ton VOC reduced was estimated on ARB's SCM cost analysis. This average cost-effectiveness was weighted by emission reductions across all the proposed limits. Details on the assumptions used for ARB's cost analysis are provided in the "Staff Report for the Proposed Suggested Control Measures for Architectural Coatings," (ARB, 2000)

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$6,628 per ton VOC reduced.

Comments:

Status:	Last Reviewed: 2005
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Additional Information:

References:

ARB, 2000: California Air Resources Board, "Staff Report for the Proposed Suggested Control Measure for the Architectural Coatings, Volume II, Technical Support Document, Section VIII, Economic Impacts," June 2000.

Pechan 2001: E.H. Pechan & Associates, Inc., "Control Measure Development Support – Analysis of Ozone Transport Commission Model Rules," prepared for Ozone Transport Commission, March, 2001.

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: AREA

Control Measure Name: OTC Solvent Cleaning Rule

Rule Name: OTC Solvent Cleaning Rule

Pechan Measure Code: V24604

POD: 241

Application: This control establishes hardware and operating requirements for specified vapor cleaning machines, as well as solvent volatility limits and operating practices for cold cleaners.

Affected SCC:

2415305000: Solvent Utilization: Degreasing: Furniture and Fixtures (SIC 25): Cold Cleaning
2415310000: Solvent Utilization: Degreasing: Primary Metal Industries (SIC 33): Cold Cleaning
2415320000: Solvent Utilization: Degreasing: Fabricated Metal Products (SIC 34): Cold Cleaning
2415325000: Solvent Utilization: Degreasing: Industrial Machinery and Equipment (SIC 35): Cold Cleaning
2415330000: Solvent Utilization: Degreasing: Electronic and Other Elec. (SIC 36): Cold Cleaning
2415335000: Solvent Utilization: Degreasing: Transportation Equipment (SIC 37): Cold Cleaning
2415340000: Solvent Utilization: Degreasing: Instruments and Related Products (SIC 38): Cold Cleaning
2415345000: Solvent Utilization: Degreasing: Miscellaneous Manufacturing (SIC 39): Cold Cleaning
2415355000: Solvent Utilization: Degreasing: Automotive Dealers (SIC 55): Cold Cleaning
2415360000: Solvent Utilization: Degreasing: Auto Repair Services (SIC 75): Cold Cleaning
2415365000: Solvent Utilization: Degreasing: Miscellaneous Repair Services (SIC 76): Cold Cleaning
2415300000: Solvent Utilization: Degreasing: All Industries: Cold Cleaning

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
						√*				

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 66% from uncontrolled

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis:

Cost Effectiveness:

Comments:

Status:

Last Reviewed: 2005

Additional Information:

References:

SCAQMD, 1997: South Coast Air Quality Management District, "Final Staff Report for Proposed Amendments to Rule 1122 – Solvent Degreasers," June 6, 1997.

Pechan 2001: E.H. Pechan & Associates, Inc., "Control Measure Development Support – Analysis of Ozone Transport Commission Model Rules," prepared for Ozone Transport Commission, March,

AT-A-GLANCE TABLE FOR AREA SOURCES

2001.

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: AREA

Control Measure Name: OTC Consumer Products Rule

Rule Name: OTC Consumer Products Rule

Pechan Measure Code: V24607

POD: 249

Application: The OTC model rule regulates approximately 80 consumer product categories, and uses more stringent VOC content limits than the Federal rule. Examples include aerosol adhesives, floor wax strippers, dry cleaning fluids, and general purpose cleaners. It also contains administrative requirements for labeling, reporting, code-dating, and a “most restrictive limit” scenario. There is a reporting requirement, such that manufacturers may be required to submit information to the State upon written notice.

Affected SCC:

2465100000 Solvent Utilization: Miscellaneous Non-industrial: Consumer: Personal Care Products: Total: All Solvent Types

2465200000 Solvent Utilization: Miscellaneous Non-industrial: Consumer: Household Products: Total: All Solvent Types

2465400000 Solvent Utilization: Miscellaneous Non-industrial: Consumer: Automotive Aftermarket Products: Total: All Solvent Types

2465000000 Solvent Utilization: Miscellaneous Non-industrial: Consumer: All Products/Processes: Total: All Solvent Types

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
						√*				

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 39.2% from uncontrolled

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: ARB has estimated the cost of their rule to be \$1032 per ton (ARB, 1999). Since the OTC model rule emissions limits are based on California's, this value should be approximate costs that would be incurred to meet the same limits in the OTC States.

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$1032 per ton VOC reduced.

Comments:

Status:

Last Reviewed: 2005

Additional Information:

References:

ARB, 1999: California Air Resources Board, “Initial Statement of Reasons for Proposed Amendments to the California Consumer Products Regulation,” Stationary Source Division, September 1999.

Pechan 2001: E.H. Pechan & Associates, Inc., “Control Measure Development Support – Analysis of Ozone Transport Commission Model Rules,” prepared for Ozone Transport Commission, March,

AT-A-GLANCE TABLE FOR AREA SOURCES

2001

Source Category: AREA

Control Measure Name: OTC Mobile Equipment Repair and Refinishing Rule

Rule Name: OTC MER Rule

Pechan Measure Code: V24608

POD: 251

Application: The rule includes VOC limits for paints used in the industry that are consistent with the Federal limits for the mobile equipment refinishing materials. The rule also establishes requirements for using improved transfer efficiency application equipment and enclosed spray gun cleaning, and requires minimal training.

In addition to requiring that refinishing materials meet the Federal VOC limits, the model rule proposes a number of pollution prevention initiatives. For example, the coating application requirements specify using improved transfer efficiency spray equipment such as high volume-low pressure (HVLP) equipment.

Affected SCC:

2401080000 Marine: SIC 373, Total: All Solvent Types

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
						√*				

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 61% from uncontrolled

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: A cost of \$2,534 per ton of VOC reduced was estimated based on the use of HVLP spray guns and a gun cleaning system, as estimated for Pennsylvania for Rule 129.75.

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$2,534 per ton VOC reduced.

Comments:

Status:

Last Reviewed: 2005

Additional Information:

References:

Pechan 2001: E.H. Pechan & Associates, Inc., "Control Measure Development Support – Analysis of Ozone Transport Commission Model Rules," prepared for Ozone Transport Commission, March, 2001.

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: AREA

Control Measure Name: OTC Mobile Equipment Repair and Refinishing Rule

Rule Name: OTC MER Rule

Pechan Measure Code: V24703

POD: 247

Application: The rule includes VOC limits for paints used in the industry that are consistent with the Federal limits for the mobile equipment refinishing materials. The rule also establishes requirements for using improved transfer efficiency application equipment and enclosed spray gun cleaning, and requires minimal training.

In addition to requiring that refinishing materials meet the Federal VOC limits, the model rule proposes a number of pollution prevention initiatives. For example, the coating application requirements specify using improved transfer efficiency spray equipment such as high volume-low pressure (HVLP) equipment.

Affected SCC:

2401055000 Machinery and Equipment: SIC 35, Total: All Solvent Types

2401085000 Railroad: SIC 374, Total: All Solvent Types

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
						√*				

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 61% from uncontrolled

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: A cost of \$2,534 per ton of VOC reduced was estimated based on the use of HVLP spray guns and a gun cleaning system, as estimated for Pennsylvania for Rule 129.75.

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$2,534 per ton VOC reduced.

Comments:

Status:

Last Reviewed: 2005

Additional Information:

References:

Pechan 2001: E.H. Pechan & Associates, Inc., "Control Measure Development Support – Analysis of Ozone Transport Commission Model Rules," prepared for Ozone Transport Commission, March, 2001.

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: AREA

Control Measure Name: OTC Mobile Equipment Repair and Refinishing Rule

Rule Name: OTC MER Rule

Pechan Measure Code: V25002

POD: 250

Application: The rule includes VOC limits for paints used in the industry that are consistent with the Federal limits for the mobile equipment refinishing materials. The rule also establishes requirements for using improved transfer efficiency application equipment and enclosed spray gun cleaning, and requires minimal training.

In addition to requiring that refinishing materials meet the Federal VOC limits, the model rule proposes a number of pollution prevention initiatives. For example, the coating application requirements specify using improved transfer efficiency spray equipment such as high volume-low pressure (HVLP) equipment.

Affected SCC:

2401075000: Aircraft: SIC 372, Total: All Solvent Types

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
						√*				

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 61% from uncontrolled

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: A cost of \$2,534 per ton of VOC reduced was estimated based on the use of HVLP spray guns and a gun cleaning system, as estimated for Pennsylvania for Rule 129.75.

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$2,534 per ton VOC reduced.

Comments:

Status: **Last Reviewed:** 2005

Additional Information:

References:

Pechan 2001: E.H. Pechan & Associates, Inc., "Control Measure Development Support – Analysis of Ozone Transport Commission Model Rules," prepared for Ozone Transport Commission, March, 2001.

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: AREA

Control Measure Name: OTC Mobile Equipment Repair and Refinishing Rule

Rule Name: OTC MER Rule

Pechan Measure Code: V25403

POD: 246

Application: The rule includes VOC limits for paints used in the industry that are consistent with the Federal limits for the mobile equipment refinishing materials. The rule also establishes requirements for using improved transfer efficiency application equipment and enclosed spray gun cleaning, and requires minimal training.

In addition to requiring that refinishing materials meet the Federal VOC limits, the model rule proposes a number of pollution prevention initiatives. For example, the coating application requirements specify using improved transfer efficiency spray equipment such as high volume-low pressure (HVLP) equipment.

Affected SCC:

2401005000 Auto Refinishing: SIC 7532, Total: All Solvent Types

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
						√*				

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 61% from uncontrolled

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: A cost of \$2,534 per ton of VOC reduced was estimated based on the use of HVLP spray guns and a gun cleaning system, as estimated for Pennsylvania for Rule 129.75.

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$2,534 per ton VOC reduced.

Comments:

Status: **Last Reviewed:** 2005

Additional Information:

References:

Pechan 2001: E.H. Pechan & Associates, Inc., "Control Measure Development Support – Analysis of Ozone Transport Commission Model Rules," prepared for Ozone Transport Commission, March, 2001.

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: AREA

Control Measure Name: OTC Consumer Products Rule

Rule Name: OTC Consumer Products Rule

Pechan Measure Code: V26904

POD: 269

Application: The OTC model rule regulates approximately 80 consumer product categories, and uses more stringent VOC content limits than the Federal rule. Examples include aerosol adhesives, floor wax strippers, dry cleaning fluids, and general purpose cleaners. It also contains administrative requirements for labeling, reporting, code-dating, and a “most restrictive limit” scenario. There is a reporting requirement, such that manufacturers may be required to submit information to the State upon written notice.

Affected SCC:

2465600000 Adhesives and Sealants, Total: All Solvent Types

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
						√*				

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 39.2% from uncontrolled

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: ARB has estimated the cost of their rule to be \$1032 per ton (ARB, 1999). Since the OTC model rule emissions limits are based on California's, this value should be approximate costs that would be incurred to meet the same limits in the OTC States.

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$1032 per ton VOC reduced.

Comments:

Status: Demonstrated

Last Reviewed: 2005

Additional Information:

References:

ARB, 1999: California Air Resources Board, “Initial Statement of Reasons for Proposed Amendments to the California Consumer Products Regulation,” Stationary Source Division, September 1999.

Pechan 2001: E.H. Pechan & Associates, Inc., “Control Measure Development Support – Analysis of Ozone Transport Commission Model Rules,” prepared for Ozone Transport Commission, March, 2001.

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Automobile Refinishing

Control Measure Name: Federal Rule

Rule Name: Federal Rule

Pechan Measure Code: V24601

POD: 246

Application: This control is based on EPA proposed standards to reduce emissions of volatile organic compounds (VOC) from the use of automobile refinish coatings.

This rule applies to automobile refinish coatings that are manufactured or imported for sale or distribution in the United States. Coatings that are currently used for automobile refinishing are also used outside the automobile refinish industry (Pechan, 1998).

Affected SCC:

2401005000 Auto Refinishing: SIC 7532, Total: All Solvent Types

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
						√*				

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 37% from uncontrolled

Equipment Life: Unavailable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: EPA calculated the total costs of the regulation as the sum of the costs for necessary process modifications and employee training costs.

The total capital investment for process modifications is \$10 million, including the costs for pumping and mixing equipment capable of processing higher-solids coatings. The costs for training personnel to use the new coatings was estimated separately for coating manufacturers, distributors, and body shops. A training cost of \$425 per employee was applied to manufacturing employees, distributors, and painters at body shops. Process modification and training costs were annualized over 10 years at an interest rate of 7 percent for a total annual cost of \$4.5 million (EPA, 1995).

Cost Effectiveness: The cost effectiveness is \$118 per ton VOC reduced (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 1998

Additional Information:

EPA's documents acknowledge that research and development costs associated with formulating low-VOC coatings were not considered, since these costs are assumed to have been incurred as the result of state regulations (EPA, 1995).

AT-A-GLANCE TABLE FOR AREA SOURCES

References:

EPA, 1995: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Volatile Organic Compound Emissions from Automobile Refinishing-Background Information for Proposed Standards," Research Triangle Park, NC, EPA-453/D-95-005a, August 1995.

Pechan, 1998: E.H. Pechan & Associates, "Clean Air Act Section 812 Prospective Cost Analysis - Draft Report" prepared for prepared for U.S. Environmental Protection Agency, September 1998.

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Automobile Refinishing

Control Measure Name: CARB BARCT Limits

Rule Name: California Air Resources Board Best Available Retrofit Control Technology

Pechan Measure Code: V24602

POD: 246

Application: The CARB BARCT rule establishes VOC content limits for automobile refinishing coatings, the use of equipment that achieves a 65% transfer efficiency, cleanup of spray equipment in an enclosed system, and specifies other housekeeping procedures.

These limits apply to any coating applied to motor vehicles. Emissions from auto body refinishing can be classified in three categories (and percentage contribution): surface preparation (1.6%), coating application (91.0%), and spray gun cleaning (7.4%).

Affected SCC:

2401005000 Auto Refinishing: SIC 7532, Total: All Solvent Types

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
						√*				

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 47% from uncontrolled

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Cost effectiveness was derived from BARCT limits using a weighted average of costs from surface preparation product limits and spray gun cleaners (Pechan, 1994). Costs for reformulating preparation products are estimated to be \$900 per ton for additional equipment to facilitate longer drying times needed for these coatings. A savings of \$900 per ton is documented for the use of spray gun cleaners due to the reduction in solvent usage.

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$750 per ton VOC reduced (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 1994

Additional Information:

The low-VOC coatings that meet the BARCT limits require significantly longer drying times, and may require the purchase of additional equipment (e.g. heating lamps) in areas with weather conditions unlike California's (Pechan, 1994).

Surface preparation emissions may be reduced through the use of low VOC-preparation products. These products generally consist of more detergents (and less solvent) and must remain on the surface longer and require additional rubbing for thorough removal of dirt, grease and old paint.

Emissions from coating applications can be reduced through low VOC content coatings (high solids

AT-A-GLANCE TABLE FOR AREA SOURCES

or waterborne coatings) and/or increased transfer efficiency (e.g. high volume, low pressure spray equipment).

Equipment cleaning emissions can be reduced through the use of gun cleaners which either recirculate solvent or minimize evaporation.

References:

Pechan, 1994: E.H. Pechan & Associates, Inc., "Analysis of Incremental Emission Reductions and Costs of VOC and NOx Control Measures - Draft Report," prepared for U.S. Environmental Protection Agency, Ambient Standards Branch, Research Triangle Park, NC, September 1994.

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Automobile Refinishing

Control Measure Name: California FIP Rule (VOC content & TE)

Rule Name: California Federal Implementation Plan Rule (VOC Content & TE)

Pechan Measure Code: V24603

POD: 246

Application: The Federal Implementation Plan (FIP) rule controls VOC emissions from automobile refinishing operations. This FIP rule requires the use of low-VOC coatings or the use of an emission control system, and a transfer efficiency for all coating application equipment equivalent to that of high-volume, low-pressure (HVLP) spray equipment (Radian, 1994).

The FIP rule applies to all facilities that apply coatings of any kind to motor vehicles and mobile equipment for the purpose of on-site refinishing and modification. Affected facilities include auto body repair/paint shops, production auto body paint shops, new car dealer repair/paint shops, fleet operator repair/paint shops, custom-made car fabrication facilities, and truck body builders (Radian, 1994).

Affected SCC:

2401005000 Auto Refinishing: SIC 7532, Total: All Solvent Types

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
						√*				

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 89% from uncontrolled

Equipment Life: Unavailable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The cost of implementing this FIP rule was estimated using data developed by the SCAQMD for Rule 1151 (SCAQMD, 1991). The SCAQMD Rule 1151 regulates emissions from solvent operations, however the FIP rule does not. To account for the difference in regulations, the cost is calculated as the difference between the total cost of SCAQMD Rule 1151 and the cost of solvent operations. The cost effectiveness was calculated based on an estimate of 26.4 tpd VOC reduced (Radian, 1994).

Cost of Rule 1151: \$201,100 per day

Cost of Solvent Operations: \$11,500 per day

Difference = \$189,600 per day

Cost Effectiveness = Difference / Tons Reduced Per Day = \$7,200 per ton VOC reduced

Note: All costs are in 1990 dollars.

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$7,200 per ton VOC reduction.

AT-A-GLANCE TABLE FOR AREA SOURCES

Comments:

Status: Demonstrated**Last Reviewed:** 1994

Additional Information:

CARB notes that the FIP rule is based largely on SCAQMD Rule 1151 and that portions of the FIP rule are based on the CARB Determination of Reasonably Available Control Technology and Best Available Retrofit Control Technology for Automotive Refinishing Operations (CARB, 1991).

References:

CARB, 1991: California Air Resources Board Criteria Pollutants Branch, Stationary Source Division, "Determination of Reasonably Available Control Technology and Best Available Retrofit Control Technology for Automotive Refinishing Operations," January 1991.

Radian, 1994: Radian Corporation, "Technical Support Document for Proposed FIP Automotive Refinishing Operations Rule 52.961(c)," prepared for U.S. Environmental Protection Agency, February 1994.

SCAQMD, 1991: South Coast Air Quality Management District, Rule Development Division, "Supplemental Staff Report, Proposed Amended Rule 1151 - Motor Vehicle and Mobile Equipment Non-Assembly Line Coating Operations," August 1991.

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Bakery Products

Control Measure Name: Incineration >100,000 lbs bread

Rule Name: Not Applicable

Pechan Measure Code: V27102

POD: 271

Application: The control measure is based on the regulation adopted by the BAAQMD, which assumes emissions reductions from the use of catalytic incinerators. These incinerators use a catalyst to achieve very high control efficiencies at relatively low operating temperatures (320 to 650 °C).

The BAAQMD control requirements affect only large, commercial bread bakeries, classified under SCC 2302050000.

Affected SCC:

2302050000 Bakery Products, Total

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
						√*				

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 40% from uncontrolled

Equipment Life: 10 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Costs for catalytic incinerators were developed using a spreadsheet cost model provided by EPA. The spreadsheet model uses the procedures documented in the OAQPS Control Cost Manual for developing costs for catalytic incinerators (EPA, 1990). Oven parameters that were used in the spreadsheet model to calculate capital, operating and maintenance (O&M) costs, and cost effectiveness were provided by EPA (1992).

Fixed annual costs for taxes, insurance, and administration were estimated as 4 percent of total installed capital costs. Capital recovery costs were estimated using a factor of 0.1424 (based on a 7 percent interest rate and 10-year equipment life) times total installed capital costs.

The spreadsheet model was used to estimate costs as follows:

Capital costs= \$3,880 per ton VOC reduced

O&M costs= \$800 per ton VOC reduced

The equipment costs in the spreadsheet model provided by EPA are in 1988 dollars. The costs were indexed to 1990 dollars using the 1988-1990 equipment cost indices for catalytic incinerators (M&S, 1991; EPA, 1995).

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$1,470 per ton VOC reduced (1990\$).

AT-A-GLANCE TABLE FOR AREA SOURCES

Comments:

Status: Demonstrated**Last Reviewed:** 1997

Additional Information:

The BAAQMD regulation was estimated to achieve an overall source category control level of 39.9 percent in 1993 (Schultz, 1997). The BAAQMD's regulation was selected as the basis for the control measure because their regulation limits control requirements to large, commercial bread bakeries.

References:

EPA, 1990: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual, Fourth Edition," EPA-450/3-90-006, Research Triangle Park, NC, January 1990.

EPA, 1992: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Alternative Control Technology Document for Bakery Oven Emissions," Research Triangle Park, NC, December 1992.

EPA, 1995: U.S. Environmental Protection Agency, "Office of Air Quality Planning and Standards, Escalation Indices for Air Pollution Control Costs," EPA-452/R-95-006, Research Triangle Park, NC, October 1995.

M&S, 1991: "Chemical Engineering, Marshall & Swift Equipment Cost Indices," February 1991.

Schultz, 1997: Schultz, S., BAAQMD, San Francisco, CA, personal communication with M. Cohen, E.H. Pechan & Associates, Inc. February 20, 1997.

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Commercial Adhesives

Control Measure Name: Federal Consumer Solvents Rule

Rule Name: Federal Consumer Solvents Rule

Pechan Measure Code: V26901

POD: 269

Application: This Federal rule provides uniformity over the state-level content limits that commercial adhesives must meet. The rule sets maximum allowable VOC content limits for 24 consumer product categories. The final rule was promulgated in 1998.

The proposed Federal rule covers those consumer products that EPA determined to be most amenable to regulation, and were capable of achieving significant VOC reductions without significant effects on product quality or price (EPA, 1995). Affected adhesives are used in a wide variety of industrial applications, including product manufacturing, packaging, construction, and installation of metal, wood and plastic materials. For most adhesives, VOC emissions occur as the result of evaporation of solvents during transfer, drying, surface preparation, and clean-up operations.

Affected SCC:

2465600000 Adhesives and Sealants, Total: All Solvent Types

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
						√*				

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 25% from uncontrolled

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Cost values are based upon the EPA's Economic Impact and Regulatory Flexibility Analysis of the Regulation of VOCs from Consumer Products (EPA, 1996).

The cost estimate in the Federal rule was converted from 1991 dollars to 1990 dollars using the producer price index for SIC code 284 (BLS, 1996).

Cost Effectiveness: An estimate of \$232 (in 1990 dollars) per ton VOC reduced is used in AirControlINET.

Comments:

Status: Demonstrated

Last Reviewed: 1999

Additional Information:

The Federal rule required companies to do what they (in most cases) had already done to comply with CARB's and other states' rules in existence before EPA's efforts.

AT-A-GLANCE TABLE FOR AREA SOURCES

References:

BLS, 1996: Bureau of Labor Statistics, U.S. Department of Labor, "Producer Price Indices," Washington, DC, 1996.

EPA, 1995: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Study of Volatile Organic Compound Emissions from Consumer and Commercial Products, Report to Congress," EPA-453/R-94-066-A, Research Triangle Park, NC, March 1995.

EPA, 1996: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Economic Impact and Regulatory Flexibility Analysis of the Regulation of VOCs from Consumer Products," EPA-453/R-96-014, Research Triangle Park, NC, October 1996.

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Commercial Adhesives

Control Measure Name: CARB Mid-Term Limits

Rule Name: California Air Resources Board Mid-Term Limits (Based on SCAQMD Rule 1168)

Pechan Measure Code: V26902

POD: 269

Application: CARB rules included in this control are Phase I and Phase II Consumer Products and Mid-Term I and Mid-Term II Consumer Products regulations. The CARB Mid-Term (and Near-Term) limits set VOC content standards for various consumer products. The regulations were implemented over a time period from 1993 to 2005. These regulations assume that emissions will be reduced through product reformulation (CARB, 1990).

Sources affected by these regulations include, but are not limited to, antiperspirants and deodorants, aerosol coating products, and hairspray. Affected sources are classified under SCC 2465600000.

Affected SCC:

2465600000 Adhesives and Sealants, Total: All Solvent Types

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
						√*				

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 55% from uncontrolled

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Cost effectiveness were estimated for CARB's consumer product regulations, and the overall cost effectiveness for mid-term limits measure (includes all limits for near-term and mid-term) were based on the emission reductions and costs for individual regulations.

Average Cost Effectiveness for Individual Regulations:

Antiperspirants and Deodorants = \$0.92 per pound

Phase I Consumer Products = \$0.90 per pound

Phase II Consumer Products = \$0.55 per pound

Aerosol Coating Products = \$3.03 per pound

Hairspray = \$2.25 per pound

Mid-Term I Consumer Products = \$0.25 per pound

Mid-Term II Consumer Products = \$0.40 per pound

It should be noted that CARB expects costs to be incurred only through the first 15 years or so of regulation, due to research and development and changes to production lines.

AT-A-GLANCE TABLE FOR AREA SOURCES

Cost Effectiveness: The estimate used in AirControlNET is \$2,192 (in 1990 dollars) per ton VOC reduced, based on the individual average cost effectiveness estimates of CARB regulations.

Comments:

Status: Demonstrated

Last Reviewed: 1996

Additional Information:

The CARB plans to reduce VOC emissions from the consumer products category using three types of control measures: near-term, mid-term, and long-term measures. Near-term measures include VOC content limits for antiperspirants, Phase I consumer products, and Phase II consumer products. The CARB is implementing the near-term measures as follows:

1) Initial VOC limits for:

Antiperspirants by 1993,
Phase I consumer products by 1994,
Phase II consumer products by 1995;

2) More stringent VOC content limits for:

Antiperspirants by 1999,
Selected Phase I products by 1996 and 1999,
Selected Phase II products by 1997 and 1998.

Some of CARB's standards were identified as technology-forcing because they cannot be met by manufacturers at the time of rule adoption, but can be met within the time-frame provided by the regulation.

The CARB's mid-term controls apply to additional consumer products that are not affected by the near-term measures. These measures are to achieve an additional 25 percent reduction in overall VOC emissions from consumer products by 2005.

References:

CARB, 1990: California Air Resources Board, Stationary Source Division, "Proposed Regulation to Reduce Volatile Organic Compound Emissions from Consumer Products - Technical Support Document," August 1990.

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Commercial Adhesives

Control Measure Name: CARB Long-Term Limits

Rule Name: California Air Resources Board Long-Term Limits (Based on SCAQMD Rule 1168)

Pechan Measure Code: V26903

POD: 269

Application: The CARB's long-term measures depend on future technological innovation and market incentive methods that can be developed and implemented before 2010.

Sources affected by these regulations include, but are not limited to, antiperspirants and deodorants, aerosol coating products, and hairspray. Affected sources are classified under SCC 2465600000.

Affected SCC:

2465600000 Adhesives and Sealants, Total: All Solvent Types

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
						√*				

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 85% from uncontrolled

Equipment Life: Unavailable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: An incremental cost per ton of \$4,680 is assumed, double the average cost through the mid-term limits (Pechan, 1999). In 1990 dollars, this is \$4,257 per ton. Overall cost effectiveness for this measure (combining near-term, mid-term, and long-term) is \$2,880 per ton of VOC reduced.

Cost Effectiveness: The overall cost effectiveness used in AirControlNET is \$2,880 per ton VOC reduced (1990\$).

Comments:

Status: Future

Last Reviewed: 1997

Additional Information:

References:

Pechan, 1999: E.H. Pechan & Associates, Inc., "Control Measure Evaluations: The Control Measure Data Base For the National Emission Trends Inventory (AirControlNET)," prepared for the U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, September 1999.

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Consumer Solvents

Control Measure Name: Federal Consumer Solvents Rule

Rule Name: Federal Consumer Solvents Rule

Pechan Measure Code: V24901

POD: 249

Application: This Federal rule provides uniformity over the state-level content limits that commercial adhesive must meet. The rule sets maximum allowable VOC content limits for 24 consumer product categories. The final rule was promulgated in 1998.

The proposed Federal rule covers those consumer products that EPA determined to be most amenable to regulation, and were capable of achieving significant VOC reductions without significant effects on product quality or price (EPA, 1995). Consumer products include, but are not limited to, personal care products, household cleaners and disinfectants, automotive aftermarket products, adhesives and sealants, lawn and garden products, and household insecticides. (60 FR 15264, 1995).

Affected SCC:

2465000000 All Products/Processes, Total: All Solvent Types

2465100000 Personal Care Products, Total: All Solvent Types

2465200000 Household Products, Total: All Solvent Types

2465400000 Automotive Aftermarket Products, Total: All Solvent Types

2461600000 Miscellaneous Non-Industrial: Commercial - Adhesives and Sealants

2461850000 Miscellaneous Non-Industrial: Commercial - Pesticide Application

2465900000 Misc. Non-Industrial: Consumer - Misc. Products - Not Elsewhere Classified

2495000000 All Solvent User Groups

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
						√*				

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 25% from uncontrolled

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Cost values are based upon the EPA's Economic Impact and Regulatory Flexibility Analysis of the Regulation of VOCs from Consumer Products (EPA, 1996).

The cost estimate in the Federal rule was converted from 1991 dollars to 1990 dollars using the producer price index for SIC code 284 (BLS, 1996).

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$232 per ton VOC reduced (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 1999

AT-A-GLANCE TABLE FOR AREA SOURCES

Additional Information:

The Federal rule required companies to do what they (in most cases) had already done to comply with CARB's and other states' rules in existence before EPA's efforts.

References:

BLS, 1996: Bureau of Labor Statistics, U.S. Department of Labor, "Producer Price Indices," Washington, DC, 1996.

EPA, 1995: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Study of Volatile Organic Compound Emissions from Consumer and Commercial Products, Report to Congress," EPA-453/R-94-066-A, Research Triangle Park, NC, March 1995.

61FR14531, 1996: Federal Register, "National Volatile Organic Compound Emission Standards for Consumer Products, Proposed Rule," Volume 61, Number 64, April 2, 1996.

EPA, 1996: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Economic Impact and Regulatory Flexibility Analysis of the Regulation of VOCs from Consumer Products, Draft Report, EPA-453/R-96-014, Research Triangle Park, NC, October 1996.

Moore, 1997: B. Moore, U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, personal communication with D. Crocker, E.H. Pechan & Associates, Inc., February 24, 1997.

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Consumer Solvents

Control Measure Name: CARB Mid-Term Limits

Rule Name: California Air Resources Board Consumer Products Mid-Term Limits

Pechan Measure Code: V24902

POD: 249

Application: CARB rules included in this control are Phase I and Phase II Consumer Products and Mid-Term I and Mid-Term II Consumer Products regulations. The CARB Mid-Term (and Near-Term) limits set VOC content standards for various consumer products. The regulations were implemented over a time period from 1993 to 2005. These regulations assume that emissions will be reduced through product reformulation (CARB, 1990).

Consumer products affected by this control measure include, but are not limited to, personal care products, household cleaners and disinfectants, automotive aftermarket products, adhesives and sealants, lawn and garden products, and household insecticides.

Affected SCC:

2465000000 All Products/Processes, Total: All Solvent Types
2465100000 Personal Care Products, Total: All Solvent Types
2465200000 Household Products, Total: All Solvent Types
2465400000 Automotive Aftermarket Products, Total: All Solvent Types
2461600000 Miscellaneous Non-Industrial: Commercial - Adhesives and Sealants
2461850000 Miscellaneous Non-Industrial: Commercial - Pesticide Application
2465900000 Misc. Non-Industrial: Consumer - Misc. Products - Not Elsewhere Classified
2495000000 All Solvent User Groups

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
						√/*				

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 55% from uncontrolled

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Cost effectiveness were estimated for CARB's consumer product regulations, and the overall cost effectiveness for mid-term limits measure (includes all limits for near-term and mid-term) were based on the emission reductions and costs for individual regulations.

Average Cost Effectiveness for Individual Regulations:

Antiperspirants and Deodorants = \$0.92 per pound
Phase I Consumer Products = \$0.90 per pound
Phase II Consumer Products = \$0.55 per pound
Aerosol Coating Products = \$3.03 per pound
Hairspray = \$2.25 per pound
Mid-Term I Consumer Products = \$0.25 per pound

AT-A-GLANCE TABLE FOR AREA SOURCES

Mid-Term II Consumer Products = \$0.40 per pound

It should be noted that CARB expects costs to be incurred only through the first 15 years or so of regulation, due to research and development and changes to production lines.

Cost Effectiveness: The estimate used in AirControlNET is \$2,192 (in 1990 dollars) per ton VOC reduced, based on the individual average cost effectiveness estimates of CARB regulations.

Comments:

Status: Demonstrated	Last Reviewed: 1999
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Additional Information:

The CARB plans to reduce VOC emissions from the consumer products category using three types of control measures: near-term, mid-term, and long-term measures. Near-term measures include VOC content limits for antiperspirants, Phase I consumer products, and Phase II consumer products. The CARB is implementing the near-term measures as follows:

1) Initial VOC limits for:

Antiperspirants by 1993,
Phase I consumer products by 1994, and
Phase II consumer products by 1995;

2) More stringent VOC content limits for:

Antiperspirants by 1999,
Selected Phase I products by 1996 and 1999, and
Selected Phase II products by 1997 and 1998.

Some of CARB's standards were identified as technology-forcing because they cannot be met by manufacturers at the time of rule adoption, but can be met within the time-frame provided by the regulation.

The CARB's mid-term controls (Phase III) apply to additional consumer products that are not affected by the near-term measures. These measures are to achieve an additional 25 percent reduction in overall VOC emissions from consumer products by 2005.

References:

CARB, 1990: California Air Resources Board, Stationary Source Division, "Proposed Regulation to Reduce Volatile Organic Compound Emissions from Consumer Products - Technical Support Document," August 1990.

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Consumer Solvents

Control Measure Name: CARB Long-Term Limits

Rule Name: California Air Resources Board Consumer Products Long-Term Limits Rule

Pechan Measure Code: V24903

POD: 249

Application: The CARB's long-term measures depend on future technological innovation and market incentive methods that can be developed and implemented before 2010.

Consumer products affected by this control measure include, but are not limited to, personal care products, household cleaners and disinfectants, automotive aftermarket products, adhesives and sealants, lawn and garden products, and household insecticides.

Affected SCC:

2465000000 All Products/Processes, Total: All Solvent Types
2465100000 Personal Care Products, Total: All Solvent Types
2465200000 Household Products, Total: All Solvent Types
2465400000 Automotive Aftermarket Products, Total: All Solvent Types
2461600000 Miscellaneous Non-Industrial: Commercial - Adhesives and Sealants
2461850000 Miscellaneous Non-Industrial: Commercial - Pesticide Application
2465900000 Misc. Non-Industrial: Consumer - Misc. Products - Not Elsewhere Classified
2495000000 All Solvent User Groups

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
						√*				

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 85% from uncontrolled

Equipment Life: Unavailable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: An incremental cost per ton of \$4,680 is assumed, double the average cost through the mid-term limits (Pechan, 1999). In 1990 dollars, this is \$4,257 per ton. Overall cost effectiveness for this measure (combining near-term, mid-term, and long-term) is \$2,880 per ton of VOC reduced.

Cost Effectiveness: The overall cost effectiveness used in AirControlNET is \$2,880 per ton VOC reduced (1990\$).

Comments:

Status: Future

Last Reviewed: 1999

Additional Information:

References:

Pechan, 1999: E.H. Pechan & Associates, Inc., "Control Measure Evaluations: The Control Measure Data Base For the National Emission Trends Inventory (AirControlNET)," prepared for the U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, September 1999.

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Cutback Asphalt

Control Measure Name: Switch to Emulsified Asphalts

Rule Name: Not Applicable

Pechan Measure Code: V27201

POD: 272

Application: Generic control measure replacing VOC-containing cutback asphalt with VOC-free emulsified asphalt.

Affected SCC:

2461021000 Cutback Asphalt, Total: All Solvent Types

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
						√*				

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 100% from uncontrolled

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Pechan estimates that the cost effectiveness is \$15 per ton to require driveways to be paved with non-hydrocarbon asphalt (Pechan, 1997).

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$15 per ton VOC reduced.

Comments:

Status: Demonstrated

Last Reviewed: 1997

Additional Information:

References:

Pechan, 1997: E.H. Pechan & Associates, Inc., "Control Measure Evaluations Prepared for Southeast Pennsylvania Ozone Stakeholders Group."

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Electrical/Electronic Coating

Control Measure Name: MACT Standard

Rule Name: Maximum Achievable Control Technology for Electrical/Electronic Coating

Pechan Measure Code: V25301

POD: 253

Application: MACT control options for reducing VOC emissions from the manufacture of electronics equipment include the use of low-VOC coatings and add-on control equipment (spray guns, venting to emission control systems, and paint booth enclosures).

This control applies to the miscellaneous electronic equipment coating source category, including VOC emissions resulting from the manufacture of circuit boards and components, including resistors, transistors, semiconductors, coils, and transformers. Emissions for this source category are classified under SCC 2401065000.

Affected SCC:

2401065000 Electronic and Other Electrical: SIC 36 - Total: All Solvent Types

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
						√*				

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 36% from uncontrolled

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: At the time this was developed, the MACT for Miscellaneous Metal Parts and Products Surface Coating Operations had not yet been promulgated. Pechan used an estimate of \$5,000 per ton VOC reduced based on a control efficiency of 36% (Pechan, 1997).

Cost Effectiveness: The annual cost is \$5,000 per ton VOC reduction (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 1997

Additional Information:

References:

E.H. Pechan & Associates, Inc., "Integrated Ozone, Particulate Matter, and Regional Haze Cost Analysis - Methodology and Results," prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Office of Air Quality Planning and Standards, June 6, 1997.

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Electrical/Electronic Coating

Control Measure Name: SCAQMD Rule

Rule Name: South Coast Air Quality Management District Rule 1164

Pechan Measure Code: V25302

POD: 253

Application: SCAQMD Rule 1116 requires: a fully covered area, low/no-VOC solvents, or an approved emissions control system for solvent cleaning operations, photoresist operations and solvent clean-up operations. An alternative emission control plan pursuant to Rule 108 may be submitted in place of the measures listed above (SCAQMD, 1995).

This control applies to the miscellaneous electronic equipment coating source category, including VOC emissions resulting from the manufacture of circuit boards and components, including resistors, transistors, semiconductors, coils, and transformers. Emissions for this source category are classified under SCC 2401065000.

Affected SCC:

2401065000 Electronic and Other Electrical: SIC 36 - Total: All Solvent Types

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
						√*				

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 70% from uncontrolled

Equipment Life: Unavailable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The cost inputs for achieving VOC reductions from this source category are based on cost data from the SCAQMD. Factors affecting costs include product reformulations (SCAQMD, 1996).

Cost Effectiveness: The annual cost for the South Coast measure used in AirControlNET is \$5,976 (in 1990 dollars) per ton of VOC reduced (SCAQMD, 1996).

A cost range of \$2,000 for reformulated coatings and \$9,600 per ton for add-on equipment is noted (Pechan, 1994).

Comments:

Status: Demonstrated

Last Reviewed: 1997

Additional Information:

This control measure proposes to reduce VOC emissions from electronic components manufacturing operations through the application of several control methods. These control methods include installation of add-on control equipment, material reformulations, and improved operating procedures. Such control methods are currently required for semiconductor manufacturing operations and are also expected to be applicable to this source category due to the similarity in

AT-A-GLANCE TABLE FOR AREA SOURCES

operations.

Add-on control devices such as carbon adsorption, and thermal and catalytic incinerators could be used to capture and/or eliminate organic compound emissions from the operation exhaust streams. In addition, development of low-VOC, high-solids content, and water-based formulations could provide another alternative for reducing VOC emissions from this source category. Further emission reductions could also be expected through adoption of improved procedures resulting in lower solvent usage and/or evaporation (SCAQMD, 1988).

Assuming that the proposed control methods would have the same control efficiency as achieved in semiconductor manufacturing operations, implementation of this control measure is expected to be 70 percent efficient in reducing VOC emissions from this source category.

References:

Pechan, 1994: E.H. Pechan & Associates, Inc., "Analysis of Incremental Emission Reductions and Costs of VOC and NO_x Control Measures - Draft Report," prepared for U.S. Environmental Protection Agency, Ambient Standards Branch, Research Triangle Park, NC, September 1994.

Pechan , 1997: E.H. Pechan & Associates: "Additional Control Measure Evaluation for the Integrated Implementation of the Ozone and Particulate Matter National Ambient Air Quality Standards, and Regional Haze Program," prepared for U.S. Environmental Protection Agency, July 1997.

SCAQMD, 1988: South Coast Air Quality Management District, Rule Development Division, "Staff Report on the Proposed Rule 1164 - Semiconductor Manufacturing," April 1988.

SCAQMD, 1995: South Coast Air Quality Management District, "Rule 1164 - Semiconductor Manufacturing," January 1993.

SCAQMD, 1996: South Coast Air Quality Management District, "1997 Air Quality Management Plan - Appendix IV-A - Stationary and Mobile Source Control Measures," August 1996.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Fabric Printing, Coating and Dyeing

Control Measure Name: Permanent Total Enclosure (PTE)

Rule Name: Not Applicable

Pechan Measure Code: V40202

POD: 202

Application: A PTE is an enclosure used to surround a source of emissions so that all, or nearly all, emissions are captured and contained, usually for discharge to a control device. Fabric printing, coating and dyeing is performed in the textile manufacturing industry in order to:

- ☐ prepare fiber and subsequently manufacture yarn, threads, braids, twine, and cordage
- ☐ manufacture broadwoven fabrics, narrow woven fabrics, knit fabrics, and carpets and rugs from yarn
- ☐ dye and finish fiber, yarn, fabrics, and knit apparel
- ☐ coat, waterproof, or otherwise treat fabrics
- ☐ perform integrated manufacturing of knit apparel and other finished articles from yarn
- ☐ manufacture felt goods, lacegoods, nonwoven fabrics, and miscellaneous textiles.

The EPA evaluated VOC emission control options for the fabric printing, coating and dyeing industry including the use of a PTE in conjunction with a thermal oxidizer in the MACT standard-setting process for this source category.

Affected SCC:

40204001
40204002
40204003
40204004
40204010
40204011
40204012
40204013
40204020
40204021
40204022
40204023
40204121
40204130
40204140
40204150
40204151
40204152
40204160
40204161
40204162
40204221
40204230
40204240
40204250

AT-A-GLANCE TABLE FOR POINT SOURCES

40204251
 40204252
 40204260
 40204261
 40204262
 40204321
 40204330
 40204340
 40204350
 40204351
 40204352
 40204360
 40204361
 40204362
 40204421
 40204430
 40204431
 40204432
 40204435
 40204440
 40204441
 40204442
 40204443
 40204450

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
						√*				

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 97% from uncontrolled

Equipment Life: 30 years (PTE); 15 years (thermal oxidizer)

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The cost analysis is based on an average of PTE and oxidizer capital and operating and maintenance costs developed for four model fabric coating plants evaluated by EPA for the Printing, Coating and Dyeing of other Fabrics and Textiles MACT standard (40 CFR Part 63 Subpart OOOO). Consistent with the OAQPS Control Cost Manual, an interest rate of 7% was used to determine the capital recovery factor. Although the PTE is expected to have a life of 30 years, PTE costs were annualized over a 15 year period, representing the expected catalytic oxidizer life. Each PTE was assumed to capture 100% of all VOC emissions. All captured emissions were assumed to be vented to a catalytic thermal oxidizer achieving a 97% control efficiency. Therefore, the net VOC control efficiency is 97%. Year 1997 dollars were specified for cost calculations in the EPA background document for the printing and publishing industry. The EPA also evaluated costs based on the use of a thermal (non-catalytic) oxidizer; the annualized costs were higher than for the use of a catalytic oxidizer.

Cost Effectiveness: The cost effectiveness is \$1,343 per ton VOC reduction (1997\$). The cost effectiveness is based on an annualized capital cost of \$62,900 and an annual

AT-A-GLANCE TABLE FOR POINT SOURCES

operation and maintenance (O&M) cost of \$121,242 averaged over four model textile manufacturing plants.

Comments:

Status:	Last Reviewed:
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Additional Information:

Rule penetration estimated to be 100% in Air ControlNET, while state or local areas might choose to require only sources above a certain size to comply with a regulation requiring PTEs. In such a case, the rule penetration value would be less than 100 percent.

References:

EPA, 2002: U.S. Environmental Protection Agency, "Technical Support Document: Printing, Coating and Dyeing of Fabrics and Other Textiles Proposed NESHAP", EPA 453/R-02-010, June 2002.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual", Sixth Edition, document EPA/452/B-02-001, January 2002.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Flexographic Printing

Control Measure Name: Permanent Total Enclosure (PTE)

Rule Name: Not Applicable

Pechan Measure Code: V40201

POD: 201

Application: A PTE is an enclosure used to surround a source of emissions so that all, or nearly all, emissions are captured and contained, usually for discharge to a control device. Flexographic printing is classified into two categories: wide-web and narrow-web flexographic printing. Wide-web flexographic printing is used to print flexible and rigid paper, plastic and aluminum foil packaging, newspapers, magazines, directories, paper towels, etc., printed shower curtains and wallpaper. Flexographic newspaper printing is also starting to replace older letterpress technology. Narrow-web flexographic printing is primarily used for printing and adhesive application on paper, foil and film tags and labels. The EPA evaluated VOC emission control options for the flexographic printing industry including the use of a PTE in conjunction with a thermal oxidizer in the MACT standard-setting process for this source category.

Affected SCC:

40500301 Printing/Publishing, General, Printing: Flexographic
40500311 Printing/Publishing, General, Printing: Flexographic
40500312 Printing/Publishing, General, Printing: Flexographic
40500313 Printing/Publishing, General, Printing: Flexographic: Propyl Alcohol Cleanup
40500314 Printing/Publishing, General, Printing: Flexographic: Propyl Alcohol Cleanup
40500315 Printing/Publishing, General, Flexographic: Steam: Water-based
40500316 Printing/Publishing, General, Flexographic: Steam: Water-based
40500317 Printing/Publishing, General, Flexographic: Steam: Water-based
40500318 Printing/Publishing, General, Flexographic: Steam: Water-based in Ink
40500319 Printing/Publishing, General, Flexographic: Steam: Water-based Ink Storage
40500414 Printing/Publishing, General, Flexographic: Propyl Alcohol Cleanup

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
						√*				

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 95% from uncontrolled

Equipment Life: 30 years (PTE); 15 years (thermal oxidizer)

Rule Effectiveness: 100% for point and area sources

Penetration: 100%

Cost Basis: The cost analysis is based on an average of PTE and oxidizer capital and operating and maintenance costs developed for three model flexographic printing plants evaluated by EPA for the Printing and Publishing MACT standard (40 CFR Part 63 Subpart KK). Consistent with the OAQPS Control Cost Manual, an interest rate of 7% was used to determine the capital recovery factor. Although the PTE is expected to have a life of 30 years, PTE costs were annualized over 15 years (the expected life of the thermal oxidizer). Each PTE was assumed to capture 100% of all VOC emissions. All captured emissions were assumed to be vented to a thermal oxidizer having a 95% control efficiency. Therefore, the net VOC control efficiency is 95%. Year 1993 dollars were specified for cost calculations in the EPA background

AT-A-GLANCE TABLE FOR POINT SOURCES

document for the printing and publishing industry.

Cost Effectiveness: The cost effectiveness is \$9,947 per ton VOC reduction (1993\$). The cost effectiveness is based on an annualized capital cost of \$97,120 and an annual operation and maintenance (O&M) cost of \$1,236,652 averaged over three model flexographic printing plants

Comments:

Status: Demonstrated

Last Reviewed: 2004

Additional Information:

References:

EPA, 1995: U.S. Environmental Protection Agency, "National Emission Standards for Hazardous Air Pollutants: Printing and Publishing Industry Background Information for Proposed Standards", February 1995.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual", Sixth Edition, document EPA/452/B-02-001, January 2002.

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Graphic Arts

Control Measure Name: Use of Low or No VOC Materials

Rule Name: Not Applicable

Pechan Measure Code: V30301

POD: 303

Application: This control measure calls for the application of RACT-level controls to small graphic arts sources. This control measure, based on one developed by STAPPA/ALAPCO, requires the use of low or no-VOC materials to reduce VOC emissions from graphic arts sources.

This control applies to lithography, letterpress, rotogravure, and flexography graphic, and other graphic arts applications.

Affected SCC:

2425000000 All Processes, Total: All Solvent Types

2425010000 Lithography, Total: All Solvent Types

2425020000 Letterpress, Total: All Solvent Types

2425030000 Rotogravure, Total: All Solvent Types

2425040000 Flexography, Total: All Solvent Types

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
						√*				

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 65% from uncontrolled

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Pechan assumes an average cost effectiveness from the range given by STAPPA/ALAPCO.

Cost Effectiveness: STAPPA/ALAPCO (1993) estimated a range of cost effectiveness from \$3,500 to \$4,800 per ton VOC reduced.

The cost effectiveness use in AirControlNET is \$4,150 per ton VOC reduced. (1993\$)

Comments:

Status: Demonstrated

Last Reviewed: 1999

Additional Information:

References:

STAPPA/ALAPCO, 1993: "Meeting the 15 Percent Rate of Progress Requirement Under the Clean Air Act: A Menu of Options," September 1993.

AT-A-GLANCE TABLE FOR MOBILE SOURCES

Source Category: Highway Vehicles - Gasoline Engine

Control Measure Name: Federal Reformulated Gasoline (RFG)

Rule Name: Federal Reformulated Gasoline

Pechan Measure Code: mOT2

POD: N/A

Application: This control measure represents the year round National use of Federal Reformulated gasoline in light duty gasoline vehicles in counties currently not required to use this fuel. Emission reduction benefits of NO_x, CO, and VOC are estimated using EPA's MOBILE6 model.

This control is applicable to all light duty gasoline vehicles, motor cycles, and trucks.

Affected SCC:

2201001000 Light Duty Gasoline Vehicles (LDGV), Total: All Road Types

2201020000 Light Duty Gasoline Trucks 1 (LDGT1), Total: All Road Types

2201040000 Light Duty Gasoline Trucks 2 (LDGT2), Total: All Road Types

2201070000 Heavy Duty Gasoline Vehicles (HDGV), Total: All Road Types

2201080000 Motorcycles (MC), Total: All Road Types

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
					X	√*			√	

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: The control efficiency ranged from: NO_x (-1.0 % to 1.1%; VOC (0.0 to 15.3%); CO (3.8 to 16.3%)

Equipment Life: Not Applicable

Rule Effectiveness: Not applicable

Penetration: Not applicable

Cost Basis: The total annual cost of RFG was estimated using the number of vehicles and amount of fuel consumed by county and vehicle type. Costs were estimated on a per-vehicle basis in all counties with no RFG in the base case.

The number of vehicles was estimated by dividing the VMT by the average LDGV annual mileage accumulation rate. The annual costs for RFG is estimated assuming \$0.043 per gallon (Pechan 2002) (\$1997).

Cost Effectiveness: The cost effectiveness of RFG varies greatly by county. Cost effectiveness for VOC ranged from \$28,905,773 to \$2,498 per ton. The average C-E for VOC is \$25,093 per ton of VOC reduced (median is \$16,656 per ton). All costs are \$1997.

Comments: In some cases this control produces a slight NO_x disbenefit. The median NO_x control efficiency is -0.02 percent.

Status: Demonstrated

Last Reviewed: 2002

Additional Information:

AT-A-GLANCE TABLE FOR MOBILE SOURCES

References:

Pechan 2002: "AirControlNET Specifications and Methods for Mobile Source Controls" Memo prepared for Larry Sorrels of the US EPA, December 2002.

Source Category: Highway Vehicles - Light Duty Gasoline Engines

Control Measure Name: Basic Inspection and Maintenance Program

Rule Name: Not Applicable

Pechan Measure Code: mOT9

POD: N/A

Application: Basic I/M control measure includes idle testing of light-duty gasoline vehicles (LDGVs) for model years 1983 through 2001. Starting in 2002, all 1996 and later model year LDGVs are tested with on-board diagnostics (OBD) and all pre-96 LDGVs continue to receive the idle test. So, the NOx benefits are a result of the OBD testing.

Affected SCC:

2201001000 Light Duty Gasoline Vehicles (LDGV), Total: All Road Types

2201020000 Light Duty Gasoline Trucks 1 (LDGT1), Total: All Road Types

2201040000 Light Duty Gasoline Trucks 2 (LDGT2), Total: All Road Types

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√	√			√	√*	√	√	√	

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: The control efficiency varies by model year and vehicle type.

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Costs are estimated on a per-vehicle basis. The number of vehicles was estimated by dividing the VMT by the average LDGV annual mileage accumulation rate. The costs are for basic I/M are estimated at \$6.52 per vehicle.

Cost Effectiveness: The costs are for basic I/M are estimated at \$6.52 per vehicle.

Comments:

Status: Demonstrated

Last Reviewed: 2005

Additional Information:

References:

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Industrial Maintenance Coating

Control Measure Name: AIM Coating Federal Rule

Rule Name: Architectural and Industrial Maintenance Coatings Federal Rule

Pechan Measure Code: V22201

POD: 222

Application: This federal rule provides uniformity over the state-level content limits that AIM coating manufacturers must meet. The rule sets maximum allowable VOC content limits for 55 different categories of AIM coatings, and affects the manufacturers and importers of the coating products. VOC content limits defined in the national rule took effect on September 11, 1999. Manufacturers of FIFRA - regulated coatings had until March 10, 2000 to comply.

Sixty-four percent of the products included in the 1990 industry survey meet the VOC content limits in this rule and, therefore, there will be no costs to reformulate these products. The manufacturer of a product that does not meet the VOC content limits will be required to reformulate the product if it will continue to be marketed, unless the manufacturer chooses to use an alternative compliance option such as the exceedance fee or tonnage exemption provision.

In AirControlNET, this specific control measure applies only to industrial maintenance coatings.

Affected SCC:

2401100000 Industrial Maintenance Coatings, Total: All Solvent Types

2401990000 All Surface Coating Categories, Total: All Solvent Types

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
						√*				

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 20% from uncontrolled

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The cost estimates are based upon information provided to EPA by industry representatives during the regulatory negotiation process. Industry representatives estimated the level of effort required by a representative firm to research and develop a new prototype coating to be 2.5 scientist-years over a 3-year time period. EPA calculated an annualized cost of \$17,772 per reformulation (1991 dollars) based on an assumed cost of \$100,000 per scientist-year as amortized over an assumed repopulation cycle of 2.5 years.

The estimated average cost to reformulate a product was \$87,000. The total estimated national cost of the AIM Coating Federal rule is 25.6 million per year (1991 dollars).

Cost Effectiveness: EPA estimated emission reductions of 106,000 tons of VOC per year so that the cost effectiveness is computed as \$228 per ton VOC reduction (1990\$)..

AT-A-GLANCE TABLE FOR AREA SOURCES

Comments: The EPA did not account for potential cost differences for reformulating coatings to various content limits. Instead, EPA assumed that a reformulation has a certain cost to manufacturers regardless of the target content limit, or the anticipated VOC reduction (Ducey, 1997).

Status: Demonstrated

Last Reviewed: 1997

Additional Information:

In its analysis of the proposed federal rule, EPA assumed that the cost of product reformulation would bring the VOC content limit for each noncompliant coating down to the level of the standards. The EPA, however, noted the likelihood that some manufacturers will likely reduce the VOC content of their coatings to levels significantly below the limits in the rule (EPA, 1996). The at-the-limit assumption, therefore, likely results in emission reductions being understated. In its cost analysis, insufficient data were available for EPA to distinguish reformulation costs between different coating types (i.e., the reformulation cost for flat paints is equal to the reformulation cost for all other affected paint types). The EPA noted the likelihood of reformulation costs varying from product to product (EPA, 1995).

References:

Ducey, 1997: E. Ducey, U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, personal communication with D. Crocker, E.H. Pechan & Associates, Inc., February 13, 1997.

EPA, 1995: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Economic Impact and Regulatory Flexibility Analysis of the Proposed Architectural Coatings Federal Rule," Research Triangle Park, NC. March 1995.

EPA, 1996: U.S. Environmental Protection Agency, Emission Standards Division, Office of Air and Radiation, "Architectural Coatings - Background for Proposed Standards, Draft Report," March 1996.

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Industrial Maintenance Coating

Control Measure Name: South Coast Phase I

Rule Name: South Coast AQMD Rule 1113 - Architectural Coatings

Pechan Measure Code: V22202

POD: 222

Application: The Phase I rule is an amendment to SCAQMD's existing architectural coatings rule that establishes more stringent VOC content limits for flat, multi-color, traffic, and lacquer coatings. These VOC limits in the SCAQMD for multi-color, traffic, and lacquer coatings took effect on January 1, 1998, while the Phase I limits for flat coating took effect on January 1, 2001.

Reductions in VOC emissions from these coatings are achieved through the use of product reformulation and product substitution.

Affected SCC:

2401100000 Industrial Maintenance Coatings, Total: All Solvent Types

2401990000 All Surface Coating Categories, Total: All Solvent Types

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
						√*				

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 34% from uncontrolled

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: For the Phase I amendment, a SCAQMD report documents cost per gallon, total annual cost, emission reduction and cost-effectiveness values for each of the four regulated coating types (SCAQMD, 1996).

The SCAQMD estimated that manufacturers would use an acetone formulation with an associated cost of \$2 per gallon to meet the proposed 550 grams per liter (g/L) VOC limit for lacquers. For flats, South Coast estimated a zero cost for complying with the near-term 100 g/L limit since most flats sold in California are already in compliance with this limit. For traffic and multi-color coatings, the SCAQMD estimated that a cost savings was likely to be associated with reformulation due to a decrease in the cost of input materials. (The estimated magnitude of the savings is not documented in the SCAQMD report.)

Costs were estimated by multiplying the cost per gallon data to total gallons sold. The resulting weighted average cost effectiveness value was converted to 1990 dollars using the 1995:1990 producer price index for Standard Industrial Classification (SIC) code 2851 (Paints and Allied Products).

Because capital cost information was not available, capital costs were not estimated for this analysis.

Cost Effectiveness: Calculated cost-effectiveness values range from \$3,300 to \$4,600 per ton

AT-A-GLANCE TABLE FOR AREA SOURCES

depending on the specified limit and coating type. The cost effectiveness range is attributable to the wide diversity of coatings.

AirControlNET uses a cost effectiveness of \$1,443 per ton VOC reduction based on a weighted average of national sales data by coating type (EPA, 1996) (1990\$).

Comments:

Status: Demonstrated**Last Reviewed:** 1999

Additional Information:

References:

CARB, 1989: California Air Resources Board, Stationary Source Division, "ARB-CAPCOA Suggested Control Measure for Architectural Coatings, Technical Support Document," July 1989.

EPA, 1996: U.S. Environmental Protection Agency, Emission Standards Division, Office of Air and Radiation, "Architectural Coatings - Background for Proposed Standards, Draft Report," EPA-453/R-95-009a, March 1996.

SCAQMD, 1996: South Coast Air Quality Management District, "Proposed Modifications to the Appendices of the Draft 1997 Air Quality Management Plan," October 1996.

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Industrial Maintenance Coating

Control Measure Name: South Coast Phase II

Rule Name: South Coast AQMD Rule 1113 - Architectural Coatings

Pechan Measure Code: V22203

POD: 222

Application: Phase II represents an effort to lower the VOC content limits for non-flat industrial maintenance primers and topcoats, sealers, undercoaters, and quick-dry enamels. The rule requires manufacturers of the coatings sold in the SCAQMD to meet the VOC limit requirements provided in the rule between 2002 and 2006.

Reductions in VOC emissions from these coatings are achieved through the use of product reformulation and product substitution.

Affected SCC:

2401100000 Industrial Maintenance Coatings, Total: All Solvent Types

2401990000 All Surface Coating Categories, Total: All Solvent Types

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
						√*				

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 47% from uncontrolled

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: For the Phase II amendments, the SCAQMD completed a socioeconomic impact assessment (SCAQMD, 1999). SCAQMD assumed a 10 percent price increase per gallon for compliant coatings meeting Phase II and estimated the cost based on the number of gallons produced. Costs vary significantly among individual coatings categories.

Because capital cost information was not available, capital costs were not estimated for this analysis.

Cost Effectiveness: AirControlNET uses a cost effectiveness of \$4,017 per ton VOC reduction (1990\$).

Comments: Cost data for Phase II controls are sparse and not well-documented.

Status: Demonstrated

Last Reviewed: 1996

Additional Information:

The South Coast notes that the process of collecting reformulation cost data for these categories is very complex due to the resin technology used in lower-VOC, high-performance industrial maintenance coatings (silicon-based resins, or polyurethanes) and the number of resin systems involved (Berry, 1997).

AT-A-GLANCE TABLE FOR AREA SOURCES

References:

Berry, 1997: N. Berry, South Coast Air Quality Management District, personal communication with D. Crocker, E.H. Pechan & Associates, Inc., March 4, 1997.

SCAQMD, 1999: South Coast Air Quality Management District, "Addendum to Staff Report: Final Socioeconomic Impact Assessment, Proposed Amendments to Rule 1113," May 1999.

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Industrial Maintenance Coating

Control Measure Name: South Coast Phase III

Rule Name: South Coast AQMD Rule 1113 - Architectural Coatings

Pechan Measure Code: V22204

POD: 222

Application: Phase III applies to additional consumer products that are not affected by Phase I or II. The rule requires manufacturers to limit VOC content of the specified coatings sold in the SCAQMD using a phased-in approach specifying compliance dates that depend on the coating type. Compliance dates range from 1/1/03 to 7/1/08.

Reductions in VOC emissions from these coatings are achieved through the use of product reformulation and product substitution.

Affected SCC:

2401100000 Industrial Maintenance Coatings, Total: All Solvent Types

2401990000 All Surface Coating Categories, Total: All Solvent Types

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
						√*				

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 73% from uncontrolled

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: SCAQMD has not yet estimated the costs for implementing the Phase III limits. As an estimate, Pechan uses the highest incremental cost effectiveness estimate for any individual product for the Phase II amendments of \$26,000 per ton (1998 dollars). This value is about double the average of Phase II products. This cost estimate is highly uncertain as no specific cost data are available (Pechan, 1999).

Because capital cost information was not available, capital costs were not estimated for this analysis.

Cost Effectiveness: AirControlNET uses an overall cost effectiveness of \$10,059 per ton VOC reduction (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 1996

Additional Information:

The Phase III controls apply to additional consumer products that are not affected by the near-term measures. These measures, which are expected to take effect between 2000 and 2005, are expected to result in an additional 25 percent VOC reduction from consumer products.

AT-A-GLANCE TABLE FOR AREA SOURCES

References:

Pechan, 1999: E.H. Pechan & Associates, Inc., "Control Measure Evaluations: The Control Measure Data Base For the National Emission Trends Inventory (AirControlNET)," prepared for the U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, 1999.

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Machinery, Equipment, and Railroad Coating

Control Measure Name: SCAQMD Limits

Rule Name: South Coast Air Quality Management District Rule 1107 - Coating of Metal Parts and Products

Pechan Measure Code: V24702

POD: 247

Application: The SCAQMD amended rule 1107 sets stringent VOC emission limits for metal coatings. VOC emissions can be reduced by using reformulated low-VOC content compliant coatings, powder coating for both general and high gloss coatings, UV curable coatings, high transfer efficiency coating applications, and increased effectiveness of add-on control equipment (SCAQMD, 1996).

The metal coating source category classifies emissions that result from the coating of metal parts and products including machinery and equipment (SCC 2401055000) and railroad rolling stock (SCC 2401085000).

Affected SCC:

2401055000 Machinery and Equipment: SIC 35, Total: All Solvent Types

2401085000 Railroad: SIC 374, Total: All Solvent Types

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
						√*				

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 55% from uncontrolled

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The cost inputs for achieving VOC reductions from this source category were for this analysis based on cost data from the SCAQMD Rule 1107. Factors affecting cost include product reformulations (SCAQMD, 1996).

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$2,027 per ton VOC reduction (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 1994

Additional Information:

The SCAQMD originally adopted its Rule 1107 - Coating of Metal Parts and Products - in 1979, as part of California's SIP. Since 1979, SCAQMD amended the rule several times to adjust the compliance schedule, and to modify provisions due to delayed progress in the development and use of compliant coatings.

The SCAQMD notes that add-on control equipment is considerably more expensive than low-VOC coating reformulation.

AT-A-GLANCE TABLE FOR AREA SOURCES

References:

Pechan, 1994: E.H. Pechan & Associates, Inc., "Analysis of Incremental Emission Reductions and Costs of VOC and NOx Control Measures," prepared for U.S. Environmental Protection Agency, Ambient Standards Branch, Research Triangle Park, NC, September 1994.

SCAQMD, 1996: South Coast Air Quality Management District. "1997 Air Quality Management Plan - Appendix IV-A. Stationary and Mobile Source Control Measures," August 1996.

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Marine Surface Coating (Shipbuilding)

Control Measure Name: MACT Standard

Rule Name: Maximum Achievable Control Technology for Marine Surface Coating

Pechan Measure Code: V25101

POD: 251

Application: The MACT standard requires the use of low-VOC coatings and work practices that would minimize evaporative emissions from all affected marine coatings sources (EPA, 1992). The final rule was promulgated December 1995.

Sources affected by this control measure are all major facilities involved in shipbuilding or ship repair (EPA, 1992).

Affected SCC:

2401080000 Marine: SIC 373, Total: All Solvent Types

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
						√*				

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 24% from uncontrolled

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs for model plants with emissions less than 100 tpy are used to estimate the overall cost effectiveness (Pechan, 1998). EPA assumed that no additional equipment is required for any facility and capital costs are therefore zero (EPA, 1994). Implementation of this regulation is expected to result in nationwide annualized costs for existing shipyards of about \$2 million (1992\$), for a cost effectiveness of \$2,090 per ton of VOC reduced (1990\$) (60FR64330, 1995). EPA stated that since most of the sources are in NAAs, the costs for the NESHAP also reflect costs associated with CTG compliance.

Cost Effectiveness: \$2,090 per ton VOC reduced (1990\$) is the cost effectiveness used in AirControlNET (60FR64330, 1995).

Comments:

Status: Demonstrated

Last Reviewed: 1998

Additional Information:

References:

EPA, 1992: U.S. Environmental Protection Agency, "Fact Sheet - Proposed NESHAP BID for Shipbuilding and Ship Repair Facilities (Surface Coating)," 1992. Retrieved August 1998 from <http://www.epa.gov/ttnatw01/shipb/shipbpg.html>.

EPA, 1994: U.S. Environmental Protection Agency, "Alternative Control Techniques Document: Surface Coating Operations at Shipbuilding and Ship Repair Facilities," Office of Air Quality

AT-A-GLANCE TABLE FOR AREA SOURCES

Planning and Standards, Research Triangle Park, NC, April, 1994.

60FR64330, 1995: Federal Register "National Emission Standards for Hazardous Air Pollutants for Shipbuilding and Ship Repair (surface coating) Operations," Vol. 60, December 1995.

Pechan, 1998: E.H. Pechan & Associates, "Clean Air Act Section 812 Prospective Cost Analysis - Draft Report" prepared for U.S. Environmental Protection Agency, September 1998.

Source Category: Marine Surface Coating (Shipbuilding)

Control Measure Name: Add-On Controls

Rule Name: Not Applicable

Pechan Measure Code: V25102

POD: 251

Application: This control measure is generic in that it represents potential add-on controls available for this source category. Add-on controls include thermal incinerators, catalytic incinerators, and a combination of carbon absorbers and incinerators.

Affected SCC:

2401080000 Marine: SIC 373, Total: All Solvent Types

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
						√*				

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 90% from uncontrolled

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The cost is based on estimates for small industrial sources to install add on control options. The highest costs for add-on controls are associated with specialized and small plants (Pechan, 1999).

Cost Effectiveness: The cost effectiveness is \$8,937 per ton VOC reduced (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 1997

Additional Information:

References:

Pechan, 1999: E.H. Pechan & Associates, Inc., "Control Measure Evaluations: The Control Measure Data Base For the National Emission Trends Inventory (AirControlNET) - Draft Report," prepared for the U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, September 1999.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Metal Can Surface Coating Operations

Control Measure Name: Permanent Total Enclosure (PTE)

Rule Name: Not Applicable

Pechan Measure Code: V40203

POD: 203

Application: A PTE is an enclosure used to surround a source of emissions so that all, or nearly all, emissions are captured and contained, usually for discharge to a control device. A metal can is defined as a “usually cylindrical metal container”, but governmental agencies and industry groups use differing criteria to identify cans including shape, materials, capacity, phase of product contained, and material thickness (gauge). Decorative tins, bottle caps and jar lids are also included in the can coating category since many of these items are coated on the same line where can coating takes place. Cans consist of can bodies and can ends.

Metal can surface coating facilities include two-piece beverage can body facilities, two-piece food can body facilities, one-piece aerosol can body facilities, sheetcoating facilities, three-piece food can body assembly facilities, three-piece non-food can body assembly facilities, and end lining facilities.

EPA evaluated VOC emission control options for the two-piece beverage can, two-piece food can and sheetcoating facilities using a PTE in conjunction with a thermal oxidizer in the MACT standard-setting process for this source category.

Affected SCC:

40201702 Surface Coating Operations, Metal Can Coating, Cleaning/Pretreatment
40201703 Surface Coating Operations, Metal Can Coating, Coating Mixing
40201704 Surface Coating Operations, Metal Can Coating, Coating Storage
40201705 Surface Coating Operations, Metal Can Coating, Equipment Cleanup
40201706 Surface Coating Operations, Metal Can Coating, Solvent Storage
40201721 Surface Coating Operations, Metal Can Coating, Two Piece Exterior Base Coating
40201722 Surface Coating Operations, Metal Can Coating, Interior Spray Coating
40201723 Surface Coating Operations, Metal Can Coating, Sheet Base Coating (Interior)
40201724 Surface Coating Operations, Metal Can Coating, Sheet Base Coating (Exterior)
40201725 Surface Coating Operations, Metal Can Coating, Side Seam Spray Coating
40201726 Surface Coating Operations, Metal Can Coating, End Sealing Compound (Also See 40201736 & -37)
40201727 Surface Coating Operations, Metal Can Coating, Lithography
40201728 Surface Coating Operations, Metal Can Coating, Over Varnish
40201729 Surface Coating Operations, Metal Can Coating, Exterior End Coating
40201731 Surface Coating Operations, Metal Can Coating, Three-piece Can Sheet Base Coating
40201732 Surface Coating Operations, Metal Can Coating, Three-piece Can Sheet Lithographic Coating Line
40201733 Surface Coating Operations, Metal Can Coating, Three-piece Can-side Seam Spray Coating
40201734 Surface Coating Operations, Metal Can Coating, Three-piece Can Interior Body Spray Coating
40201735 Surface Coating Operations, Metal Can Coating, Two-piece Can Coating Line
40201736 Surface Coating Operations, Metal Can Coating, Two-piece Can End Sealing Compound
40201737 Surface Coating Operations, Metal Can Coating, Three Piece Can End Sealing Compound
40201738 Surface Coating Operations, Metal Can Coating, Two Piece Can Lithographic Coating

AT-A-GLANCE TABLE FOR POINT SOURCES

Line

40201739 Surface Coating Operations, Metal Can Coating, Three Piece Can Coating Line (All Coating Solvent Emission Points)

40201799 Surface Coating Operations, Metal Can Coating, Other Not Classified

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
						√*				

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: Expected to be 95% from uncontrolled.

Equipment Life: 30 years (PTE); 10 years (thermal oxidizer)

Rule Effectiveness: 100% for point and area sources

Penetration: 100%

Cost Basis: The cost analysis is based on an average of PTE and oxidizer capital and operating and maintenance costs developed in an EPA background document for three model metal can coating plants evaluated by EPA for the Metal Can Surface Coating MACT standard (40 CFR Part 63 Subpart KKKK). Consistent with the OAQPS Control Cost Manual, an interest rate of 7% was used to determine the capital recovery factor. Although PTE costs were annualized over a 10 year period, PTE life is expected to be 30 years, also consistent with the OAQPS Control Cost Manual. Each PTE was assumed to capture 100% of all VOC emissions. All captured emissions were assumed to be vented to thermal oxidizer. The EPA background document does not specify year dollars, so the cost basis is assumed to be in terms of 2002 dollars, consistent with the year of issuance of the background document.

Cost Effectiveness: The cost effectiveness is \$8,469 per ton HAP reduction (2002\$). The cost effectiveness is based on total annualized capital and operation/maintenance (O&M) costs of \$49,862,900 and total HAP reductions of 5,888 tons per year for all three facilities combined.

Comments:

Status: Demonstrated

Last Reviewed: 2004

Additional Information:

References:

EPA, 2002: U.S. Environmental Protection Agency, "National Emission Standards for Hazardous Air Pollutants (NESHAP) for Source Category Surface Coating of Metal Cans: Background Information for Proposed Standards", November 2002.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual", Sixth Edition, document EPA/452/B-02-001, January 2002.

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Metal Coil & Can Coating

Control Measure Name: MACT Standard

Rule Name: Maximum Achievable Control Technology for Metal Coil & Can Coating

Pechan Measure Code: V22301

POD: 223

Application: This control measure represents a 10-year MACT source category, also covered by a CTG. Control methods for reducing VOC emissions from metal can and coil coating operations include the use of low-VOC coatings and add-on control equipment.

Coatings are applied to metal cans and coils to improve appearance and prevent corrosion. This rule is assumed to cover both two and three piece can and coil coating. Area source VOC emissions for the metal can and coil coating source category are classified under SCCs 2401040000 and 2401045000, respectively.

Affected SCC:

2401040000 Metal Cans: SIC 341, Total: All Solvent Types

2401045000 Metal Coils: SIC 3498, Total: All Solvent Types

2401050000 Miscellaneous Finished Metals: SIC 34 - (341 + 3498), Total: All Solvent Types

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
						√*				

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 36% from uncontrolled

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: At the time this measure was developed the 10-year MACT had not been proposed, thus control costs effectiveness was estimated to be \$1,000 for a VOC emissions reduction of 36% (Pechan, 1997).

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$1,000 per ton VOC reduced (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 1997

Additional Information:

EPA promulgated a MACT standard for this category in June 2002.

References:

Pechan, 1997: E.H. Pechan & Associates, Inc., "Integrated Ozone, Particulate Matter, and Regional Haze Cost Analysis - Methodology and Results," prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Office of Air Quality Planning and Standards, June 1997.

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Metal Coil & Can Coating

Control Measure Name: BAAQMD Rule 11 Amended

Rule Name: Bay Area Air Quality Management District Rule 11 - Hazardous Pollutants (Amended)

Pechan Measure Code: V22302

POD: 223

Application: The San Francisco Bay Area AQMD has adopted VOC content limits for body spray coatings for both two and three piece cans and set VOC limits for end sealing compounds for non-food products; and set limits for interior and exterior body sprays used on drums, pails, and lids (BAAQMD, 1999). This control measure is based on the 1997 amendment to the rule.

Coatings are applied to metal cans and coils to improve appearance and prevent corrosion. This rule is assumed to cover both two and three piece can and coil coating. Area source VOC emissions for the metal can and coil coating source category are classified under SCCs 2401040000 and 2401045000, respectively.

Affected SCC:

2401040000 Metal Cans: SIC 341, Total: All Solvent Types

2401045000 Metal Coils: SIC 3498, Total: All Solvent Types

2401050000 Miscellaneous Finished Metals: SIC 34 - (341 + 3498), Total: All Solvent Types

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
						√*				

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 42% from uncontrolled

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The cost analysis is based up on the San Francisco Bay Area VOC content limits, Rule 11 amendments. This amendment to Rule 11 is expected to further reduce emissions by 9 percent from the original rule at a cost effectiveness of \$8,400 per ton. The year of dollars is not given in the control measure summary, so 1997 dollars is assumed since this was the year of adoption of the regulation. In 1990 dollars, this is \$8,074 per ton, bringing the overall reduction to \$2,007 per ton at 42 percent reduction from uncontrolled emissions.

Cost Effectiveness: The cost effectiveness is \$2,007 per ton VOC reduction (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 1999

Additional Information:

References:

BAAQMD, 1999: Bay Area Air Quality Management District, "San Francisco Bay Area Ozone Attainment Plan for the 1-Hour National Ozone Standard, Appendix B - Control Measure Descriptions," June 1999.

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Metal Coil & Can Coating

Control Measure Name: Incineration

Rule Name: Not Applicable

Pechan Measure Code: V22303

POD: 223

Application: This is a generic control measure based on the use of incineration to reduce VOC emissions from metal coil and can coating facilities.

Coatings are applied to metal cans and coils to improve appearance and prevent corrosion. This rule is assumed to cover both two and three piece can and coil coating. Area source VOC emissions for the metal can and coil coating source category are classified under SCCs 2401040000 and 2401045000, respectively.

Affected SCC:

2401040000 Metal Cans: SIC 341, Total: All Solvent Types

2401045000 Metal Coils: SIC 3498, Total: All Solvent Types

2401050000 Miscellaneous Finished Metals: SIC 34 - (341 + 3498), Total: All Solvent Types

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
						√*				

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 90% from uncontrolled

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Pechan estimates that the cost effectiveness is \$8,937 per ton to require incineration of VOC emissions from metal coil and can coating facilities (Pechan, 1998).

Cost Effectiveness: A cost effectiveness of \$8,937 per ton VOC reduced is used in AirControlNET (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 1998

Additional Information:

References:

Pechan, 1998: E.H. Pechan & Associates: Clean Air Act Section 812 Prospective Cost Analysis - Draft Report. Prepared for prepared for U.S. Environmental Protection Agency. September 1998.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Metal Furniture Surface Coating Operations

Control Measure Name: Permanent Total Enclosure (PTE)

Rule Name: Not Applicable

Pechan Measure Code: V40204

POD: 204

Application: A PTE is an enclosure used to surround a source of emissions so that all, or nearly all, emissions are captured and contained, usually for discharge to a control device. Metal furniture surface coating operations involve:

- Surface preparation of the metal furniture prior to coating application
- Preparation of a coating for application (e.g., mixing in additives, dissolving resins)
- Application of a coating to metal furniture
- Flashoff, drying, and curing following coating application
- Cleaning of equipment used in the coating application operation
- Storage of coatings, additives, and cleaning materials
- Conveyance of coatings, additives, and cleaning materials from storage areas to mixing areas or to coating application areas, either manually or by automated means
- Handling and conveyance of waste materials generated by the surface coating operation.

The EPA evaluated VOC emission control options for the metal furniture coating industry including the use of a PTE in conjunction with a thermal oxidizer in the MACT standard-setting process for this source category.

Affected SCC:

40202501 Surface Coating Operations, Miscellaneous Metal Parts, Coating Operation
40202502 Surface Coating Operations, Miscellaneous Metal Parts, Cleaning/Pretreatment
40202503 Surface Coating Operations, Miscellaneous Metal Parts, Coating Mixing
40202504 Surface Coating Operations, Miscellaneous Metal Parts, Coating Storage
40202505 Surface Coating Operations, Miscellaneous Metal Parts, Equipment Cleanup
40202510 Surface Coating Operations, Miscellaneous Metal Parts, Prime Coat Application
40202511 Surface Coating Operations, Miscellaneous Metal Parts, Prime Coat Application: Spray, High Solids
40202512 Surface Coating Operations, Miscellaneous Metal Parts, Prime Coat Application: Spray, Water-borne
40202515 Surface Coating Operations, Miscellaneous Metal Parts, Prime Coat Application: Flashoff
40202520 Surface Coating Operations, Miscellaneous Metal Parts, Topcoat Application
40202521 Surface Coating Operations, Miscellaneous Metal Parts, Topcoat Application: Spray, High Solids
40202522 Surface Coating Operations, Miscellaneous Metal Parts, Topcoat Application: Spray, Water-borne
40202523 Surface Coating Operations, Miscellaneous Metal Parts, Topcoat Application: Dip
40202524 Surface Coating Operations, Miscellaneous Metal Parts, Topcoat Application: Flow Coat
40202525 Surface Coating Operations, Miscellaneous Metal Parts, Topcoat Application: Flashoff
40202531 Surface Coating Operations, Miscellaneous Metal Parts, Conveyor Single Flow
40202532 Surface Coating Operations, Miscellaneous Metal Parts, Conveyor Single Dip
40202533 Surface Coating Operations, Miscellaneous Metal Parts, Conveyor Single Spray
40202534 Surface Coating Operations, Miscellaneous Metal Parts, Conveyor Two Coat, Flow and Spray
40202535 Surface Coating Operations, Miscellaneous Metal Parts, Conveyor Two Coat, Dip and

AT-A-GLANCE TABLE FOR POINT SOURCES

Spray

40202536 Surface Coating Operations, Miscellaneous Metal Parts, Conveyor Two Coat, Spray

40202537 Surface Coating Operations, Miscellaneous Metal Parts, Manual Two Coat, Spray and Air Dry

40202542 Surface Coating Operations, Miscellaneous Metal Parts, Single Coat Application: Spray, High Solids

40202543 Surface Coating Operations, Miscellaneous Metal Parts, Single Coat Application: Spray, Water-borne

40202544 Surface Coating Operations, Miscellaneous Metal Parts, Single Coat Application: Dip

40202545 Surface Coating Operations, Miscellaneous Metal Parts, Single Coat Application: Flow Coat

40202546 Surface Coating Operations, Miscellaneous Metal Parts, Single Coat Application: Flashoff

40202599 Surface Coating Operations, Miscellaneous Metal Parts, Other Not Classified

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
						√*				

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 95% from uncontrolled

Equipment Life: 30 years (PTE); 10 years (thermal oxidizer)

Rule Effectiveness: 100% for point and area sources

Penetration: 100%

Cost Basis: The cost analysis is based on an average of PTE and oxidizer capital and operating and maintenance costs developed for three model metal furniture manufacturing plants evaluated by EPA for the Metal Furniture Surface Coating MACT standard (40 CFR Part 63 Subpart RRRR). Consistent with the OAQPS Control Cost Manual, an interest rate of 7% was used to determine the capital recovery factor. Each PTE was assumed to capture 100% of all VOC emissions. All captured emissions were assumed to be vented to a regenerative thermal oxidizer having 95% heat recovery and achieving a 95% control efficiency. Therefore, the net VOC control efficiency is 95%. Year 1998 dollars were specified for cost calculations in the EPA background document for the printing and publishing industry.

Cost Effectiveness: The cost effectiveness is \$19,321 per ton VOC reduction (1998\$). The cost effectiveness is based on an annualized capital cost of \$625,266 and an annual operation and maintenance (O&M) cost of \$738,787 averaged over three model metal furniture manufacturing plants.

Comments:

Status: Demonstrated

Last Reviewed: 2004

Additional Information:

References:

EPA, 2001: U.S. Environmental Protection Agency, "National Emission Standards for Hazardous Air Pollutants: Metal Furniture Surface Coating -- Background Information for Proposed Standards", October 2001.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual", Sixth Edition, document EPA/452/B-02-001, January 2002.

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Metal Furniture, Appliances, Parts

Control Measure Name: MACT Standard

Rule Name: Maximum Achievable Control Technology for Metal Furniture, Appliances, Parts

Pechan Measure Code: V24501

POD: 245

Application: The MACT for metal furniture, appliances and parts requires facilities to limit air toxic emissions through low-VOC materials and pollution prevention techniques (EPA, 2002). The final rule was proposed April 2002, but has not yet been promulgated.

The metal coating source category classifies emissions that result from the coating of metal parts and products including furniture (SCC 2401025000), appliances (SCC 2401060000), and miscellaneous manufacturing (SCC 2401090000).

Affected SCC:

2401025000 Metal Furniture: SIC 25, Total: All Solvent Types

2401060000 Large Appliances: SIC 363, Total: All Solvent Types

2401090000 Miscellaneous Manufacturing, Total: All Solvent Types

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
						√*				

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 36% from uncontrolled

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: At the time this control was developed the MACT for metal furniture, appliances and parts had not been developed. Pechan estimated a cost effectiveness of \$1,000 per ton VOC reduced based on a 36% control efficiency (Pechan, 1997).

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$1,000 per ton VOC reduced (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 1997

Additional Information:

References:

EPA, 2002: U.S. Environmental Protection Agency, "Fact Sheet - Proposed Rule to Reduce Toxic Air Pollutants From Surface Coating of Metal Furniture," March 2002. Retrieved April 28, 2003 from <http://www.epa.gov/ttn/atw/mfurn/mfurnpg.html>

Pechan, 1997: E.H. Pechan & Associates, Inc., "Integrated Ozone, Particulate Matter, and Regional Haze Cost Analysis - Methodology and Results," prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Office of Air Quality Planning and Standards, June 1997.

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Metal Furniture, Appliances, Parts

Control Measure Name: SCAQMD Limits

Rule Name: South Coast Air Quality Management District Rule 1107 - Coating of Metal Parts and Products

Pechan Measure Code: V24502

POD: 245

Application: SCAQMD Rule 1107 establishes VOC content limits for metal coatings along with application procedures and equipment requirements. The rule also mentions several options for reducing VOC emissions, including using reformulated low-VOC content compliant coatings, powder coating for both general and high gloss coatings, UV curable coatings, high transfer efficiency coating applications, and increased effectiveness of add-on control equipment. The original rule was promulgated in 1979 and has been amended several times, most recently in November 2001.

This rule applies to emissions that result from the coating of metal parts and products including furniture (SCC 2401025000), appliances (SCC 2401060000), and miscellaneous manufacturing (SCC 2401090000).

Affected SCC:

2401025000 Metal Furniture: SIC 25, Total: All Solvent Types

2401060000 Large Appliances: SIC 363, Total: All Solvent Types

2401090000 Miscellaneous Manufacturing, Total: All Solvent Types

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
						√*				

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 55% from uncontrolled

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The costs of this control are based on cost effectiveness provided by SCAQMD staff for the development of SCAQMD Rule 1107. Cost effectiveness is the average cost per ton of the expected allocation of control measures to sources in the South Coast Air Quality Basin. Factors affecting cost include product reformulations and level of add-on controls required. SCAQMD notes that add-on control equipment is considerably more expensive than low-VOC coating reformulation (SCAQMD, 1996).

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$2,027 per ton VOC reduced (1990\$).

Comments: SCAQMD notes that powder coating is very effective in reducing VOC emissions because in most cases it contains less than 3 percent VOC. Moreover, it is applied by electrostatic attraction which has high transfer efficiency (SCAQMD, 1996).

Status: Demonstrated

Last Reviewed: 1996

AT-A-GLANCE TABLE FOR AREA SOURCES

Additional Information:

Since its original adoption in 1979, SCAQMD Rule 1107 has been amended several times to adjust the compliance schedule, and modify provisions due to delayed progress in the development and use of compliant coatings (SCAQMD, 2001). This control measure represents requirements as they stood in 1996.

Coating of metal parts and products are applied to prevent corrosion and to enhance appearance.

The metal parts or products undergo a cleaning process to remove grease, dust, mill scale, or corrosion. Often they are also pretreated to improve coating adhesion. Commonly, the metal substrate is washed through an alkaline, chromate, or non-caustic solution wash and is then rinsed in water. After the final rinse, the metal normally passes through an oven to evaporate water before the coating is applied (SCAQMD, 1996).

Coating is applied either by spraying, dipping, or flow coating. Conventional, high volume low pressure (HVLP), or electrostatic spray guns are used for spraying (SCAQMD, 1996). After coating, the parts are either baked in ovens or air-dried depending on the type of coating.

References:

SCAQMD, 1996: South Coast Air Quality Management District. "1997 Air Quality Management Plan - Appendix IV-A. Stationary and Mobile Source Control Measures," August 1996.

SCAQMD, 2001: South Coast Air Quality Management District, "Rule 1107 - Coating of Metal Parts and Products," November 2001. Retrieved April 29, 2003 from www.aqmd.gov/rules/html/r1107.html.

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Miscellaneous Metal Products Coatings

Control Measure Name: MACT Standard

Rule Name: Maximum Achievable Control Technology for Miscellaneous Metal Parts and Products

Pechan Measure Code: V24701

POD: 247

Application: The 10 year MACT for Miscellaneous Metal Products Coatings sets VOC emissions limits from the source category. The rule delineates compliance options, including low-VOC coatings or an emissions capture system in conjunction with add-on controls (67FR52799, 2002). The rule was proposed in August 2002.

This control affects the metal coating source category classified under the following SCCs: railroad rolling stock (SCC 2401085000) and machinery (SCC 2401055000).

Affected SCC:

2401055000 Machinery and Equipment: SIC 35, Total: All Solvent Types

2401085000 Railroad: SIC 374, Total: All Solvent Types

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
						√*				

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 36% from uncontrolled

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: At the time this control measure was developed the MACT had not yet been proposed. Pechan estimated the cost of the MACT requirements to be \$1,000 based on a 36% control efficiency (Pechan, 1997).

Cost Effectiveness: The cost effectiveness is \$1,000 per ton VOC reduced (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 1997

Additional Information:

References:

67FR52799, 2002: Federal Register, "National Emission Standards for Hazardous Air Pollutants: Surface Coating of Miscellaneous Metal Parts and Products - Proposed Rule," Washington, DC, August 2002.

Pechan, 1997: E.H. Pechan & Associates: "Additional Control Measure Evaluation for the Integrated Implementation of the Ozone and Particulate Matter National Ambient Air Quality Standards, and Regional Haze Program," prepared for U.S. Environmental Protection Agency, July 1997..

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Motor Vehicle Coating

Control Measure Name: MACT Standard

Rule Name: Maximum Achievable Control Technology for Motor Vehicle Coating

Pechan Measure Code: V25401

POD: 254

Application: The MACT regulation is based on best available controls, as defined under the Clean Air Act, and sets specific VOC content limits on 7 categories of automobile refinish coatings (generally classified as primers and topcoats). VOC limits would be met by product reformulation, requiring the use of coatings with lower VOC content than the coatings currently in use. Most manufacturers already produce low-VOC coatings.

EPA's rule would affect approximately 5 large automobile refinish coating component manufacturers and importers and an additional 10-15 smaller manufacturers.

Affected SCC:

2401070000 Motor Vehicles: SIC 371, Total: All Solvent Types

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
						√*				

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 37% from uncontrolled

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: EPA calculated the total costs of the regulation as the sum of the costs for necessary process modifications and employee training costs. The total capital investment for process modifications is \$10 million, the majority of which is for the purchase of pumping and mixing equipment to process higher-solids coatings. The costs for training personnel to use the new coatings was estimated separately for coating manufacturers, distributors, and body shops. The total cost of the proposed rule includes coating manufacturer process modification costs, and costs for training coating manufacturer representatives, distributors, and body shop personnel.

A training cost of \$425 per employee was applied to manufacturing employees, distributors, and painters at body shops.

Process modification and training costs were annualized over 10 years at an interest rate of 7 percent for a total annual cost of \$4.5 million (EPA, 1995).

Cost Effectiveness: The cost effectiveness is \$118 per ton VOC reduced (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 1998

AT-A-GLANCE TABLE FOR AREA SOURCES

Additional Information:

In April 1996, EPA proposed a national standard to reduce VOC emissions from the use of automobile refinish coatings (61FR19005, 1996). EPA's regulation does not affect the application of automobile refinish coatings, and therefore body shops nationwide are not directly affected by the regulation's requirements. The rule is expected to reduce VOC emissions by 37 percent from baseline levels.

Research and development costs associated with formulating low-VOC coatings were not considered, since these costs are assumed to have been incurred as the result of state regulations (EPA, 1995).

References:

EPA, 1995: U.S. Environmental Protection Agency, "Volatile Organic Compound Emissions from Automobile Refinishing-Background Information for Proposed Standards," Office of Air Quality Planning and Standards, Research Triangle Park, NC, EPA-453/D-95-005a, August 1995.

61FR19005, 1996: Federal Register, "National Volatile Organic Compound Emission Standards for Automobile Refinish Coatings; Proposed Rule," Volume 61, Number 84, April 30, 1996.

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Motor Vehicle Coating

Control Measure Name: Incineration

Rule Name: Not Applicable

Pechan Measure Code: V25402

POD: 254

Application: This is a generic control measure based on the use of incineration to reduce VOC emissions from motor vehicle coating facilities.

Affected SCC:

2401070000 Motor Vehicles: SIC 371, Total: All Solvent Types

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
						√*				

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 90% from uncontrolled

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Pechan estimates that the cost effectiveness is \$8,937 per ton to require incineration of VOC emissions from motor vehicle coating facilities (Pechan, 1998).

Cost Effectiveness: A cost effectiveness of \$8,937 per ton VOC reduced is used in AirControlNET (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 1998

Additional Information:

References:

Pechan, 1998: E.H. Pechan & Associates, "Clean Air Act Section 812 Prospective Cost Analysis - Draft Report," prepared for prepared for U.S. Environmental Protection Agency, September 1998.

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Municipal Solid Waste Landfill

Control Measure Name: Gas Collection (SCAQMD/BAAQMD)

Rule Name: Bay Area Air Quality Management District Regulation 8 - Rule 34 - Gas Collection

Pechan Measure Code: V28402

POD: 284

Application: The rule is intended to limit Municipal Solid Waste (MSW) landfill emissions to prevent public nuisance and possible detriment to public health caused by exposure to such emissions. The rule, implemented in 1999, requires the installation of a gas collection system and emission control system.

This control applies to all municipal solid waste landfills.

Affected SCC:

2620000000 All Categories, Total

2620030000 Municipal, Total

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
						√*				

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 70% from uncontrolled

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: Cost effectiveness is based on information provided by the BAAQMD for the installation of gas collection systems and emissions control systems. No additional details were found in Bay Area documentation.

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$700 per ton VOC reduced, in 1992 dollars (BAAQMD, 1999).

Comments:

Status: Demonstrated

Last Reviewed: 1999

Additional Information:

References:

BAAQMD, 1999: Bay Area Air Quality Management District, Regulation 8: Organic Compounds, "Rule 34: Solid Waste Disposal Sites," Adopted May, 1984. Last Updated October, 1999.

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Nonroad Gasoline Engines

Control Measure Name: Federal Reformulated Gasoline

Rule Name: Federal Reformulated Gasoline Standards (Phase II)

Pechan Measure Code: VNRFG

POD: N/A

Application: The federal rule provides expected emission reductions from the use of reformulated gasoline as a fuel for all 2-stroke and 4-stroke nonroad gasoline engine categories.

Affected SCC:

2260001020 Recreational Equipment, Snowmobiles
2260001030 Recreational Equipment, Offroad Motorcycles/ATVs
2260001060 Recreational Equipment, Specialty Vehicles/Carts
2260002006 Construction and Mining Equipment, Tampers/Rammers
2260002009 Construction and Mining Equipment, Plate Compactors
2260002021 Construction and Mining Equipment, Paving Equipment
2260002039 Construction and Mining Equipment, Concrete/Industrial Saws
2260003030 Industrial Equipment, Sweepers/Scrubbers
2260004015 Lawn and Garden Equipment, Rotary Tillers < 6 HP (Residential)
2260004016 Lawn and Garden Equipment, Rotary Tillers < 6 HP (Commercial)
2260004020 Lawn and Garden Equipment, Chain Saws < 6 HP (Residential)
2260004021 Lawn and Garden Equipment, Chain Saws < 6 HP (Commercial)
2260004025 Lawn and Garden Equipment, Trimmers/Edgers/Brush Cutters (Residential)
2260004026 Lawn and Garden Equipment, Trimmers/Edgers/Brush Cutters (Commercial)
2260004030 Lawn and Garden Equipment, Vacuums/Vacuums (Residential)
2260004031 Lawn and Garden Equipment, Vacuums/Vacuums (Commercial)
2260004035 Lawn and Garden Equipment, Snow blowers (Residential)
2260004036 Lawn and Garden Equipment, Snow blowers (Commercial)
2260006005 Commercial Equipment, Generator Sets
2260006010 Commercial Equipment, Pumps
2260007005 Logging Equipment, Chain Saws > 6 HP
2265001030 Recreational Equipment, Offroad Motorcycles/ATVs
2265001050 Recreational Equipment, Golf Carts
2265001060 Recreational Equipment, Specialty Vehicles/Carts
2265002003 Construction and Mining Equipment, Pavers
2265002009 Construction and Mining Equipment, Plate Compactors
2265002015 Construction and Mining Equipment, Rollers
2265002021 Construction and Mining Equipment, Paving Equipment
2265002024 Construction and Mining Equipment, Surfacing Equipment
2265002030 Construction and Mining Equipment, Trenchers
2265002033 Construction and Mining Equipment, Bore/Drill Rigs
2265002039 Construction and Mining Equipment, Concrete/Industrial Saws
2265002042 Construction and Mining Equipment, Cement and Mortar Mixers
2265002060 Construction and Mining Equipment, Rubber Tire Loaders
2265002066 Construction and Mining Equipment, Tractors/Loaders/Backhoes
2265002072 Construction and Mining Equipment, Skid Steer Loaders
2265002078 Construction and Mining Equipment, Dumpers/Tenders
2265003010 Industrial Equipment, Aerial Lifts
2265003020 Industrial Equipment, Forklifts
2265003030 Industrial Equipment, Sweepers/Scrubbers
2265003040 Industrial Equipment, Other General Industrial Equipment

AT-A-GLANCE TABLE FOR AREA SOURCES

2265003050 Industrial Equipment, Other Material Handling Equipment
 2265003070 Industrial Equipment, Terminal Tractors
 2265004010 Lawn and Garden Equipment, Lawn Mowers (Residential)
 2265004011 Lawn and Garden Equipment, Lawn Mowers (Commercial)
 2265004015 Lawn and Garden Equipment, Rotary Tillers < 6 HP (Residential)
 2265004016 Lawn and Garden Equipment, Rotary Tillers < 6 HP (Commercial)
 2265004025 Lawn and Garden Equipment, Trimmers/Edgers/Brush Cutters (Residential)
 2265004026 Lawn and Garden Equipment, Trimmers/Edgers/Brush Cutters (Commercial)
 2265004030 Lawn and Garden Equipment, Vacuums/Vacuums (Residential)
 2265004031 Lawn and Garden Equipment, Vacuums/Vacuums (Commercial)
 2265004035 Lawn and Garden Equipment, Snow blowers (Residential)
 2265004036 Lawn and Garden Equipment, Snow blowers (Commercial)
 2265004040 Lawn and Garden Equipment, Rear Engine Riding Mowers (Residential)
 2265004041 Lawn and Garden Equipment, Rear Engine Riding Mowers (Commercial)
 2265004046 Lawn and Garden Equipment, Front Mowers (Commercial)
 2265004051 Lawn and Garden Equipment, Shredders < 6 HP (Commercial)
 2265004055 Lawn and Garden Equipment, Lawn and Garden Tractors (Residential)
 2265004056 Lawn and Garden Equipment, Lawn and Garden Tractors (Commercial)
 2265004066 Lawn and Garden Equipment, Chippers/Stump Grinders (Commercial)
 2265004071 Lawn and Garden Equipment, Turf Equipment (Commercial)
 2265004075 Lawn and Garden Equipment, Other Lawn and Garden Equipment (Residential)
 2265004076 Lawn and Garden Equipment, Other Lawn and Garden Equipment (Commercial)
 2265005035 Agricultural Equipment, Sprayers
 2265005040 Agricultural Equipment, Tillers > 6 HP
 2265006005 Commercial Equipment, Generator Sets
 2265006010 Commercial Equipment, Pumps
 2265006015 Commercial Equipment, Air Compressors
 2265006025 Commercial Equipment, Welders
 2265006030 Commercial Equipment, Pressure Washers
 2265007010 Logging Equipment, Shredders > 6 HP
 2265008005 Airport Ground Support Equipment, Airport Ground Support Equipment
 2282005010 Gasoline 2-Stroke, Outboard
 2282005015 Gasoline 2-Stroke, Personal Water Craft
 2282010005 Gasoline 4-Stroke, Inboard/Stern Drive

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
						√*				

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 1.4% from uncontrolled

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: EPA's Office of Mobile Sources (OMS) estimated the VOC reductions and corresponding cost effectiveness estimates resulting from the use of reformulated gasoline in nonroad vehicles for exhaust and evaporative emissions.

Cost Effectiveness: Cost effectiveness (1990\$) is based on SCC as follows (Pechan 1997):

2260001XXX \$440/ton of VOC reduced

AT-A-GLANCE TABLE FOR AREA SOURCES

2260002XXX	\$1,030/ton of VOC reduced
2260003XXX	\$2,500/ton of VOC reduced
2260004XXX	\$1,140/ton of VOC reduced
2260006XXX	\$2,225/ton of VOC reduced
2260007XXX	\$1,285/ton of VOC reduced
2260008XXX	\$8,850/ton of VOC reduced
2265001XXX	\$1,400/ton of VOC reduced
2265002XXX	\$9,250/ton of VOC reduced
2265003XXX	\$8,000/ton of VOC reduced
2265004XXX	\$5,000/ton of VOC reduced
2265005XXX	\$4,750/ton of VOC reduced
2265006XXX	\$1,8000/ton of VOC reduced
2265007XXX	\$1,5250/ton of VOC reduced
2265008XXX	\$5,750/ton of VOC reduced
2282005XXX	\$440/ton of VOC reduced
2282010XXX	\$1,400/ton of VOC reduced

Comments: This control measure is currently under review and is expected to soon be updated.

Status: Demonstrated	Last Reviewed: 1997
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Additional Information:

References:

Pechan, 1997: E.H. Pechan & Associates: "Additional Control Measure Evaluation for the Integrated Implementation of the Ozone and Particulate Matter National Ambient Air Quality Standards, and Regional Haze Program," prepared for U.S. Environmental Protection Agency, July 1997.

AT-A-GLANCE TABLE FOR NONROAD SOURCES

Source Category: Off-Highway Vehicles: All Terrain Vehicles (ATVs)

Control Measure Name: Recreational Gasoline ATV Standards

Rule Name: Recreational Gasoline ATV Standards

Pechan Measure Code: AT2010

POD: N/A

Application: This control measure is the application of EPA's Federal exhaust standards for ATV engines for implementation year 2010.

Affected SCC:

2260001030 Off-highway Vehicle Gasoline, 2-Stroke; Recreational Equipment; All Terrain Vehicles

2265001030 Off-highway Vehicle Gasoline, 4-Stroke; Recreational Equipment; All Terrain Vehicles

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√	√			√	√*			√	

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: The control efficiency varies by equipment category: PM2.5 (0-34%); PM10 (0-34%); NOX (Increase-16%); VOC (14-34%); CO (5-5%).

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: To calculate costs for the nonroad recreational gasoline ATV standards, an estimate was made of the number of affected engines for Phase 1 for each implementation year (Pechan, 2003). Near-term costs per engine for Phase 1, obtained from EPA 2002, were then applied to the corresponding number of affected engines and summed to obtain the total cost for this standard. The number of affected engines was determined by subtracting out growth in engines, and using turnover data compiled from EPA's NONROAD 2002 model.

All costs are in 2001 dollars.

Cost Effectiveness: The cost of implementing these standards varies by engine type from \$47 for 4-stroke engines to \$378 for 2-stroke engines (\$2001).

Comments:

Status: Demonstrated

Last Reviewed: 2003

Additional Information:

References:

EPA, 2002: U.S. Environmental Protection Agency, Office of Air and Radiation, Office of Transportation and Air Quality, "Final Regulatory Support Document: Control of Emissions from Unregulated Nonroad Engines," EPA420-R-02-022, September 2002.

Pechan, 2003: E.H. Pechan & Associates, Inc., "AirControlNET Development Report," Draft Report, prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, Pechan Report No. 03.08.002/9010.242, August 2003.

AT-A-GLANCE TABLE FOR NONROAD SOURCES

Source Category: Off-Highway Vehicles: All Terrain Vehicles (ATVs)

Control Measure Name: Recreational Gasoline ATV Standards

Rule Name: Recreational Gasoline ATV Standards

Pechan Measure Code: AT2015

POD: N/A

Application: This control measure is the application of EPA's Federal exhaust standards for ATV engines for implementation year 2015.

Affected SCC:

2260001030 Off-highway Vehicle Gasoline, 2-Stroke; Recreational Equipment; All Terrain Vehicles

2265001030 Off-highway Vehicle Gasoline, 4-Stroke; Recreational Equipment; All Terrain Vehicles

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√	√			√	√*			√	

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: The control efficiency varies by equipment category: PM2.5 (0-73%); PM10 (0-73%); NOX (Increase-30%); VOC (27-73%); CO (9-14%).

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: To calculate costs for the nonroad recreational gasoline ATV standards, an estimate was made of the number of affected engines for Phase 1 for each implementation year (Pechan, 2003). Near-term costs per engine for Phase 1, obtained from EPA 2002, were then applied to the corresponding number of affected engines and summed to obtain the total cost for this standard. The number of affected engines was determined by subtracting out growth in engines, and using turnover data compiled from EPA's NONROAD 2002 model.

All costs are in 2001 dollars.

Cost Effectiveness: The cost of implementing these standards varies by engine type from \$47 for 4-stroke engines to \$378 for 2-stroke engines (\$2001).

Comments:

Status: Demonstrated

Last Reviewed: 2003

Additional Information:

References:

EPA, 2002: U.S. Environmental Protection Agency, Office of Air and Radiation, Office of Transportation and Air Quality, "Final Regulatory Support Document: Control of Emissions from Unregulated Nonroad Engines," EPA420-R-02-022, September 2002.

Pechan, 2003: E.H. Pechan & Associates, Inc., "AirControlNET Development Report," Draft Report, prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, Pechan Report No. 03.08.002/9010.242, August 2003.

AT-A-GLANCE TABLE FOR NONROAD SOURCES

Source Category: Off-Highway Vehicles: All Terrain Vehicles (ATVs)

Control Measure Name: Recreational Gasoline ATV Standards

Rule Name: Recreational Gasoline ATV Standards

Pechan Measure Code: AT2020

POD: N/A

Application: This control measure is the application of EPA's Federal exhaust standards for ATV engines for implementation year 2020.

Affected SCC:

2260001030 Off-highway Vehicle Gasoline, 2-Stroke; Recreational Equipment; All Terrain Vehicles

2265001030 Off-highway Vehicle Gasoline, 4-Stroke; Recreational Equipment; All Terrain Vehicles

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√	√			√	√*			√	

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: The control efficiency varies by equipment category: PM2.5 (0-95%); PM10 (0-95%); NOX (Increase-36%); VOC (33-95%); CO (11-19%).

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: To calculate costs for the nonroad recreational gasoline ATV standards, an estimate was made of the number of affected engines for Phase 1 for each implementation year (Pechan, 2003). Near-term costs per engine for Phase 1, obtained from EPA 2002, were then applied to the corresponding number of affected engines and summed to obtain the total cost for this standard. The number of affected engines was determined by subtracting out growth in engines, and using turnover data compiled from EPA's NONROAD 2002 model.

All costs are in 2001 dollars.

Cost Effectiveness: The cost of implementing these standards varies by engine type from \$47 for 4-stroke engines to \$378 for 2-stroke engines (\$2001).

Comments:

Status: Demonstrated

Last Reviewed: 2003

Additional Information:

References:

EPA, 2002: U.S. Environmental Protection Agency, Office of Air and Radiation, Office of Transportation and Air Quality, "Final Regulatory Support Document: Control of Emissions from Unregulated Nonroad Engines," EPA420-R-02-022, September 2002.

Pechan, 2003: E.H. Pechan & Associates, Inc., "AirControlNET Development Report," Draft Report, prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, Pechan Report No. 03.08.002/9010.242, August 2003.

AT-A-GLANCE TABLE FOR NONROAD SOURCES

Source Category: Off-Highway Vehicles: All Terrain Vehicles (ATVs)

Control Measure Name: Recreational Gasoline ATV Standards

Rule Name: Recreational Gasoline ATV Standards

Pechan Measure Code: AT2030

POD: N/A

Application: This control measure is the application of EPA's Federal exhaust standards for ATV engines for implementation year 2030.

Affected SCC:

2260001030 Off-highway Vehicle Gasoline, 2-Stroke; Recreational Equipment; All Terrain Vehicles

2265001030 Off-highway Vehicle Gasoline, 4-Stroke; Recreational Equipment; All Terrain Vehicles

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√	√			√	√*			√	

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: The control efficiency varies by equipment category: PM2.5 (0-97%); PM10 (0-97%); NOX (Increase-37%); VOC (33-97%); CO (12-20%).

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: To calculate costs for the nonroad recreational gasoline ATV standards, an estimate was made of the number of affected engines for Phase 1 for each implementation year (Pechan, 2003). Near-term costs per engine for Phase 1, obtained from EPA 2002, were then applied to the corresponding number of affected engines and summed to obtain the total cost for this standard. The number of affected engines was determined by subtracting out growth in engines, and using turnover data compiled from EPA's NONROAD 2002 model.

All costs are in 2001 dollars.

Cost Effectiveness: The cost of implementing these standards varies by engine type from \$47 for 4-stroke engines to \$378 for 2-stroke engines (\$2001).

Comments:

Status: Demonstrated

Last Reviewed: 2003

Additional Information:

References:

EPA, 2002: U.S. Environmental Protection Agency, Office of Air and Radiation, Office of Transportation and Air Quality, "Final Regulatory Support Document: Control of Emissions from Unregulated Nonroad Engines," EPA420-R-02-022, September 2002.

Pechan, 2003: E.H. Pechan & Associates, Inc., "AirControlNET Development Report," Draft Report, prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, Pechan Report No. 03.08.002/9010.242, August 2003.

AT-A-GLANCE TABLE FOR NONROAD SOURCES

Source Category: Off-Highway Vehicles: Motorcycles

Control Measure Name: Recreational Gasoline Off-Highway Motorcycle Standards

Rule Name: Recreational Gasoline Off-Highway Motorcycle Standards

Pechan Measure Code: MC2010

POD: N/A

Application: This control measure is the application of EPA's Federal exhaust standards for off-highway motorcycle engines for implementation year 2010.

Motorcycles classified under SCCs 2260001010 and 2265001010 are affected by this control.

Affected SCC:

2260001010 Off-highway Vehicle Gasoline, 2-Stroke; Recreational Equipment; Motorcycles: Off-road

2265001010 Off-highway Vehicle Gasoline, 4-Stroke; Recreational Equipment; Motorcycles: Off-road

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√	√			√	√*			√	

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: The control efficiency varies by equipment category: PM2.5 (0-20%); PM10 (0-20%); NOX (Increase-7%); VOC (5-20%); CO (9-14%).

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: To calculate costs for the nonroad recreational gasoline off-highway motorcycle standards, an estimate was made of the number of affected engines for Phase 1 for each implementation year (Pechan 2003). Near-term costs per engine for Phase 1, obtained from EPA 2002, were then applied to the corresponding number of affected engines and summed to obtain the total cost for this standard. The number of affected engines was determined by subtracting out growth in engines, and using turnover data compiled from EPA's NONROAD 2002 model.

All costs are in 2001 dollars.

Cost Effectiveness: The cost per engine ranges from \$46 for 2-stroke engines to \$296 for 4-stroke engines (\$2001).

Comments:

Status: Demonstrated

Last Reviewed: 2003

Additional Information:

References:

EPA, 2002: U.S. Environmental Protection Agency, Office of Air and Radiation, Office of Transportation and Air Quality, "Final Regulatory Support Document: Control of Emissions from Unregulated Nonroad Engines," EPA420-R-02-022. September 2002.

Pechan, 2003: E.H. Pechan & Associates, Inc., "AirControlNET Development Report," Draft Report,

AT-A-GLANCE TABLE FOR NONROAD SOURCES

prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards,
Research Triangle Park, NC, Pechan Report No. 03.08.002/9010.242, August 2003.

AT-A-GLANCE TABLE FOR NONROAD SOURCES

Source Category: Off-Highway Vehicles: Motorcycles

Control Measure Name: Recreational Gasoline Off-Highway Motorcycle Standards

Rule Name: Recreational Gasoline Off-Highway Motorcycle Standards

Pechan Measure Code: MC2015

POD: N/A

Application: This control measure is the application of EPA's Federal exhaust standards for off-highway motorcycle engines for implementation year 2015.

Motorcycles classified under SCCs 2260001010 and 2265001010 are affected by this control.

Affected SCC:

2260001010 Off-highway Vehicle Gasoline, 2-Stroke; Recreational Equipment; Motorcycles: Off-road

2265001010 Off-highway Vehicle Gasoline, 4-Stroke; Recreational Equipment; Motorcycles: Off-road

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√	√			√	√*			√	

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: The control efficiency varies by equipment category: PM2.5 (0-41%); PM10 (0-41%); NOX (Increase-14%); VOC (10-40%); CO (18-29%).

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: To calculate costs for the nonroad recreational gasoline off-highway motorcycle standards, an estimate was made of the number of affected engines for Phase 1 for each implementation year (Pechan 2003). Near-term costs per engine for Phase 1, obtained from EPA 2002, were then applied to the corresponding number of affected engines and summed to obtain the total cost for this standard. The number of affected engines was determined by subtracting out growth in engines, and using turnover data compiled from EPA's NONROAD 2002 model.

All costs are in 2001 dollars.

Cost Effectiveness: The cost per engine ranges from \$46 for 2-stroke engines to \$296 for 4-stroke engines (\$2001).

Comments:

Status: Demonstrated

Last Reviewed: 2003

Additional Information:

References:

EPA, 2002: U.S. Environmental Protection Agency, Office of Air and Radiation, Office of Transportation and Air Quality, "Final Regulatory Support Document: Control of Emissions from Unregulated Nonroad Engines," EPA420-R-02-022. September 2002.

Pechan, 2003: E.H. Pechan & Associates, Inc., "AirControlNET Development Report," Draft Report,

AT-A-GLANCE TABLE FOR NONROAD SOURCES

prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards,
Research Triangle Park, NC, Pechan Report No. 03.08.002/9010.242, August 2003.

AT-A-GLANCE TABLE FOR NONROAD SOURCES

Source Category: Off-Highway Vehicles: Motorcycles

Control Measure Name: Recreational Gasoline Off-Highway Motorcycle Standards

Rule Name: Recreational Gasoline Off-Highway Motorcycle Standards

Pechan Measure Code: MC2020

POD: N/A

Application: This control measure is the application of EPA's Federal exhaust standards for off-highway motorcycle engines for implementation year 2020.

Motorcycles classified under SCCs 2260001010 and 2265001010 are affected by this control.

Affected SCC:

2260001010 Off-highway Vehicle Gasoline, 2-Stroke; Recreational Equipment; Motorcycles: Off-road

2265001010 Off-highway Vehicle Gasoline, 4-Stroke; Recreational Equipment; Motorcycles: Off-road

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√	√			√	√*			√	

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: The control efficiency varies by equipment category: PM2.5 (0-51%); PM10 (0-51%); NOX (Increase-17%); VOC (12-50%); CO (22-36%).

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: To calculate costs for the nonroad recreational gasoline off-highway motorcycle standards, an estimate was made of the number of affected engines for Phase 1 for each implementation year (Pechan 2003). Near-term costs per engine for Phase 1, obtained from EPA 2002, were then applied to the corresponding number of affected engines and summed to obtain the total cost for this standard. The number of affected engines was determined by subtracting out growth in engines, and using turnover data compiled from EPA's NONROAD 2002 model.

All costs are in 2001 dollars.

Cost Effectiveness: The cost per engine ranges from \$46 for 2-stroke engines to \$296 for 4-stroke engines (\$2001).

Comments:

Status: Demonstrated

Last Reviewed: 2003

Additional Information:

References:

EPA, 2002: U.S. Environmental Protection Agency, Office of Air and Radiation, Office of Transportation and Air Quality, "Final Regulatory Support Document: Control of Emissions from Unregulated Nonroad Engines," EPA420-R-02-022. September 2002.

Pechan, 2003: E.H. Pechan & Associates, Inc., "AirControlNET Development Report," Draft Report,

AT-A-GLANCE TABLE FOR NONROAD SOURCES

prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards,
Research Triangle Park, NC, Pechan Report No. 03.08.002/9010.242, August 2003.

AT-A-GLANCE TABLE FOR NONROAD SOURCES

Source Category: Off-Highway Vehicles: Motorcycles

Control Measure Name: Recreational Gasoline Off-Highway Motorcycle Standards

Rule Name: Recreational Gasoline Off-Highway Motorcycle Standards

Pechan Measure Code: MC2030

POD: N/A

Application: This control measure is the application of EPA's Federal exhaust standards for off-highway motorcycle engines for implementation year 2030.

Motorcycles classified under SCCs 2260001010 and 2265001010 are affected by this control.

Affected SCC:

2260001010 Off-highway Vehicle Gasoline, 2-Stroke; Recreational Equipment; Motorcycles: Off-road

2265001010 Off-highway Vehicle Gasoline, 4-Stroke; Recreational Equipment; Motorcycles: Off-road

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√	√			√	√*			√	

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: The control efficiency varies by equipment category: PM2.5 (0-52%); PM10 (0-52%); NOX (Increase-17%); VOC (12-52%); CO (23-37%).

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: To calculate costs for the nonroad recreational gasoline off-highway motorcycle standards, an estimate was made of the number of affected engines for Phase 1 for each implementation year (Pechan 2003). Near-term costs per engine for Phase 1, obtained from EPA 2002, were then applied to the corresponding number of affected engines and summed to obtain the total cost for this standard. The number of affected engines was determined by subtracting out growth in engines, and using turnover data compiled from EPA's NONROAD 2002 model.

All costs are in 2001 dollars.

Cost Effectiveness: The cost per engine ranges from \$46 for 2-stroke engines to \$296 for 4-stroke engines (\$2001).

Comments:

Status: Demonstrated

Last Reviewed: 2003

Additional Information:

References:

EPA, 2002: U.S. Environmental Protection Agency, Office of Air and Radiation, Office of Transportation and Air Quality, "Final Regulatory Support Document: Control of Emissions from Unregulated Nonroad Engines," EPA420-R-02-022. September 2002.

Pechan, 2003: E.H. Pechan & Associates, Inc., "AirControlNET Development Report," Draft Report,

AT-A-GLANCE TABLE FOR NONROAD SOURCES

prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards,
Research Triangle Park, NC, Pechan Report No. 03.08.002/9010.242, August 2003.

AT-A-GLANCE TABLE FOR NONROAD SOURCES

Source Category: Off-Highway Vehicles: Snowmobiles

Control Measure Name: Recreational Gasoline Snowmobile Standards

Rule Name: Recreational Gasoline Snowmobile Standards

Pechan Measure Code: SM2010

POD: N/A

Application: This control measure is the application of EPA's Federal exhaust standards for 2-stroke gasoline snowmobile engines for implementation year 2010.

This control applies to snowmobiles classified under SCC 2260001020.

Affected SCC:

2260001020 Off-highway Vehicle Gasoline, 2-Stroke; Recreational Equipment; Snowmobiles

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√	√			X	√*			√	

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: The control efficiency varies by pollutant: PM2.5 (10%); PM10 (10%); NOX (Increase); VOC (20%); CO (17%).

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: To calculate costs for the nonroad recreational gasoline snowmobile standards, an estimate was made of the number of affected engines by technology type for each implementation year (Pechan, 2003). Near-term costs per engine by technology type, obtained from EPA 2002, were then applied to the corresponding number of affected engines and summed to obtain the total cost for this standard. The number of affected engines was determined by subtracting out growth in engines, and using turnover data compiled from EPA's NONROAD 2002 model.

All costs are in 2001 dollars.

Cost Effectiveness: The cost of implementing these standards varies by technology type from \$57 to \$823 per engine (\$2001).

Comments:

Status: Demonstrated

Last Reviewed: 2003

Additional Information:

References:

EPA, 2002: U.S. Environmental Protection Agency, Office of Air and Radiation, Office of Transportation and Air Quality, "Final Regulatory Support Document: Control of Emissions from Unregulated Nonroad Engines," EPA420-R-02-022, September 2002.

Pechan, 2003: E.H. Pechan & Associates, Inc., "AirControlNET Development Report," Draft Report, prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards,

AT-A-GLANCE TABLE FOR NONROAD SOURCES

Research Triangle Park, NC, Pechan Report No. 03.08.002/9010.242, August 2003.

AT-A-GLANCE TABLE FOR NONROAD SOURCES

Source Category: Off-Highway Vehicles: Snowmobiles

Control Measure Name: Recreational Gasoline Snowmobile Standards

Rule Name: Recreational Gasoline Snowmobile Standards

Pechan Measure Code: SM2015

POD: N/A

Application: This control measure is the application of EPA's Federal exhaust standards for 2-stroke gasoline snowmobile engines for implementation year 2015.

This control applies to snowmobiles classified under SCC 2260001020.

Affected SCC:

2260001020 Off-highway Vehicle Gasoline, 2-Stroke; Recreational Equipment; Snowmobiles

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√	√			X	√*			√	

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: The control efficiency varies by pollutant: PM2.5 (31%); PM10 (31%); NOX (Increase); VOC (45%); CO (38%).

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: To calculate costs for the nonroad recreational gasoline snowmobile standards, an estimate was made of the number of affected engines by technology type for each implementation year (Pechan, 2003). Near-term costs per engine by technology type, obtained from EPA 2002, were then applied to the corresponding number of affected engines and summed to obtain the total cost for this standard. The number of affected engines was determined by subtracting out growth in engines, and using turnover data compiled from EPA's NONROAD 2002 model.

All costs are in 2001 dollars.

Cost Effectiveness: The cost of implementing these standards varies by technology type from \$57 to \$823 per engine (\$2001).

Comments:

Status: Demonstrated

Last Reviewed: 2003

Additional Information:

References:

EPA, 2002: U.S. Environmental Protection Agency, Office of Air and Radiation, Office of Transportation and Air Quality, "Final Regulatory Support Document: Control of Emissions from Unregulated Nonroad Engines," EPA420-R-02-022, September 2002.

Pechan, 2003: E.H. Pechan & Associates, Inc., "AirControlNET Development Report," Draft Report, prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards,

AT-A-GLANCE TABLE FOR NONROAD SOURCES

Research Triangle Park, NC, Pechan Report No. 03.08.002/9010.242, August 2003.

AT-A-GLANCE TABLE FOR NONROAD SOURCES

Source Category: Off-Highway Vehicles: Snowmobiles

Control Measure Name: Recreational Gasoline Snowmobile Standards

Rule Name: Recreational Gasoline Snowmobile Standards

Pechan Measure Code: SM2020

POD: N/A

Application: This control measure is the application of EPA's Federal exhaust standards for 2-stroke gasoline snowmobile engines for implementation year 2020.

This control applies to snowmobiles classified under SCC 2260001020.

Affected SCC:

2260001020 Off-highway Vehicle Gasoline, 2-Stroke; Recreational Equipment; Snowmobiles

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√	√			X	√*			√	

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: The control efficiency varies by pollutant: PM2.5 (49%); PM10 (49%); NOX (Increase); VOC (62%); CO (51%).

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: To calculate costs for the nonroad recreational gasoline snowmobile standards, an estimate was made of the number of affected engines by technology type for each implementation year (Pechan, 2003). Near-term costs per engine by technology type, obtained from EPA 2002, were then applied to the corresponding number of affected engines and summed to obtain the total cost for this standard. The number of affected engines was determined by subtracting out growth in engines, and using turnover data compiled from EPA's NONROAD 2002 model.

All costs are in 2001 dollars.

Cost Effectiveness: The cost of implementing these standards varies by technology type from \$57 to \$823 per engine (\$2001).

Comments:

Status: Demonstrated

Last Reviewed: 2003

Additional Information:

References:

EPA, 2002: U.S. Environmental Protection Agency, Office of Air and Radiation, Office of Transportation and Air Quality, "Final Regulatory Support Document: Control of Emissions from Unregulated Nonroad Engines," EPA420-R-02-022, September 2002.

Pechan, 2003: E.H. Pechan & Associates, Inc., "AirControlNET Development Report," Draft Report, prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards,

AT-A-GLANCE TABLE FOR NONROAD SOURCES

Research Triangle Park, NC, Pechan Report No. 03.08.002/9010.242, August 2003.

AT-A-GLANCE TABLE FOR NONROAD SOURCES

Source Category: Off-Highway Vehicles: Snowmobiles

Control Measure Name: Recreational Gasoline Snowmobile Standards

Rule Name: Recreational Gasoline Snowmobile Standards

Pechan Measure Code: SM2030

POD: N/A

Application: This control measure is the application of EPA's Federal exhaust standards for 2-stroke gasoline snowmobile engines for implementation year 2030.

This control applies to snowmobiles classified under SCC 2260001020.

Affected SCC:

2260001020 Off-highway Vehicle Gasoline, 2-Stroke; Recreational Equipment; Snowmobiles

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
	√	√			X	√*			√	

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: The control efficiency varies by pollutant: PM2.5 (58%); PM10 (58%); NOX (Increase); VOC (69%); CO (56%).

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: To calculate costs for the nonroad recreational gasoline snowmobile standards, an estimate was made of the number of affected engines by technology type for each implementation year (Pechan, 2003). Near-term costs per engine by technology type, obtained from EPA 2002, were then applied to the corresponding number of affected engines and summed to obtain the total cost for this standard. The number of affected engines was determined by subtracting out growth in engines, and using turnover data compiled from EPA's NONROAD 2002 model.

All costs are in 2001 dollars.

Cost Effectiveness: The cost of implementing these standards varies by technology type from \$57 to \$823 per engine (\$2001).

Comments:

Status: Demonstrated

Last Reviewed: 2003

Additional Information:

References:

EPA, 2002: U.S. Environmental Protection Agency, Office of Air and Radiation, Office of Transportation and Air Quality, "Final Regulatory Support Document: Control of Emissions from Unregulated Nonroad Engines," EPA420-R-02-022, September 2002.

Pechan, 2003: E.H. Pechan & Associates, Inc., "AirControlNET Development Report," Draft Report, prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards,

AT-A-GLANCE TABLE FOR NONROAD SOURCES

Research Triangle Park, NC, Pechan Report No. 03.08.002/9010.242, August 2003.

Source Category: Oil and Natural Gas Production

Control Measure Name: Equipment and Maintenance

Rule Name: Not Applicable

Pechan Measure Code: V27901

POD: 279

Application:

Affected SCC:

2310000000 All Processes, Total: All Processes

2310010000 Crude Petroleum, Total: All Processes

2310020000 Natural Gas, Total: All Processes

2310030000 Natural Gas Liquids, Total: All Processes

	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
Pollutant(s)						√*				

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 37% from uncontrolled

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis:

Cost Effectiveness: The cost effectiveness is \$317 per ton VOC reduced (1990\$).

Comments: No description of this control measure was found in Pechan's Documentation.

Status: Demonstrated

Last Reviewed: 1996

Additional Information:

References:

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Open Top Degreasing

Control Measure Name: Title III MACT Standard

Rule Name: Maximum Achievable Control Technology for Open Top Degreasing

Pechan Measure Code: V23201

POD: 232

Application: The provisions of the MACT for open top degreasing apply to individual batch vapor, in-line vapor, in-line cold, and batch cold solvent cleaning machines. VOC emissions from degreasing operations can be reduced by the use of low-VOC content solvents, and by changes in operating practices (EPA, 1993). The original MACT was promulgated in 1994.

Degreasing operations are associated with VOC emissions as a result of using solvents to clean contaminants from parts, products, tools, machinery, and equipment. This control measure is applicable to several area source SCCs beginning with "2415".

Affected SCC:

2415100000 All Industries: Open Top Degreasing, Total: All Solvent Types
2415105000 Furniture and Fixtures (SIC 25): Open Top Degreasing, Total: All Solvent Types
2415110000 Primary Metal Industries (SIC 33): Open Top Degreasing, Total: All Solvent Types
2415120000 Fabricated Metal Products (SIC 34): Open Top Degreasing, Total: All Solvent Types
2415125000 Industrial Machinery & Equipment (SIC 35)-Open Top Degreasing, Total- All Solvents
2415130000 Electronic and Other Elec. (SIC 36): Open Top Degreasing, Total: All Solvent Types
2415135000 Transportation Equipment (SIC 37): Open Top Degreasing, Total: All Solvent Types
2415140000 Instruments & Related Products (SIC 38)-Open Top Degreasing, Total-All Solvents
2415145000 Miscellaneous Manufacturing (SIC 39): Open Top Degreasing, Total: All Solvent Types

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
						√*				

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 31% from uncontrolled

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: In the cost analysis for the halogenated solvent NESHAP, EPA estimated costs by cleaner size (small, medium, large, very large, and in-line). The cost effectiveness used to estimate costs reflect a weighted average across all model facility sizes. Costs reflects distribution of emissions by model plant size.

The range of cost effectiveness is from a SAVINGS of \$148 for in-line cleaners to a cost of \$128 for small cleaners (Pechan, 1998).

Cost Effectiveness: The cost effectiveness used in AirControlINET is a SAVINGS of \$69 per ton VOC reduction (1990\$). (Pechan, 1998).

Comments:

Status: Demonstrated

Last Reviewed: 1998

AT-A-GLANCE TABLE FOR AREA SOURCES

Additional Information:

There are two basic types of solvent cleaning equipment: batch cleaners, and in-line or continuous cleaners. Batch vapor cleaners heat the solvent to boiling and create a solvent vapor zone within the machine in which parts are cleaned. In-line cleaners are enclosed devices distinguished by a conveyor system to continuously supply a stream of parts for cleaning. Batch cold cleaning machines use non-boiling solvent to clean parts. The halogenated solvent cleaning NESHAP reflects the application of the maximum achievable control technology (MACT) for all batch vapor and in-line units. For area source batch cold cleaning machines, the standard reflects the GACT (59FR61801, 1994).

References:

Pechan, 1998: E.H. Pechan & Associates, "Clean Air Act Section 812 Prospective Cost Analysis - Draft Report" prepared for U.S. Environmental Protection Agency, September 1998.

EPA, 1993: U.S. Environmental Protection Agency, "Halogenated Solvent Cleaning National Emission standards for Hazardous Air Pollutants: Background Information Document," Research Triangle Park, NC, November 4, 1993.

59FR61801, 1994: Federal Register, "National Emission Standards for Hazardous Air Pollutants: Halogenated Solvent Cleaning; Final Rule," December 2, 1994.

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Open Top Degreasing

Control Measure Name: SCAQMD 1122 (VOC content limit)

Rule Name: South Coast Air Quality Management District Rule 1122 - Solvent Degreasers (VOC Content Limit)

Pechan Measure Code: V23202

POD: 232

Application: VOC emissions from degreasing operations can be reduced by the use of low-VOC content solvents, and by changes in operating practices. This rule was originally adopted in 1979, but has since been amended to specify maximum ventilating conditions, minimize drag-out losses, eliminate some rule exemptions, expand the rule to smaller cold degreasers, and further limit the solvent content of waste materials. This rule was most recently amended in 1997.

This control measure is applicable to several area source SCCs beginning with "2415"

Affected SCC:

2415100000 All Industries: Open Top Degreasing, Total: All Solvent Types
2415105000 Furniture and Fixtures (SIC 25): Open Top Degreasing, Total: All Solvent Types
2415110000 Primary Metal Industries (SIC 33): Open Top Degreasing, Total: All Solvent Types
2415120000 Fabricated Metal Products (SIC 34): Open Top Degreasing, Total: All Solvent Types
2415125000 Industrial Machinery & Equipment (SIC 35)-Open Top Degreasing, Total- All Solvents
2415130000 Electronic and Other Elec. (SIC 36): Open Top Degreasing, Total: All Solvent Types
2415135000 Transportation Equipment (SIC 37): Open Top Degreasing, Total: All Solvent Types
2415140000 Instruments & Related Products (SIC 38)-Open Top Degreasing, Total-All Solvents
2415145000 Miscellaneous Manufacturing (SIC 39): Open Top Degreasing, Total: All Solvent Types

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
						√*				

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 76% from uncontrolled

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The cost estimates are based on studies done in the development and amendment of the SCAQMD Rule 1122. (SCAQMD, 1996; SCAQMD, 1997) The amendments are estimated to reduce emissions from solvent degreasing tanks (as opposed to hand-held cleaning) by 76 percent by using widely available no- or low-VOC solvents. The expected cost is \$1,391 per ton of VOC reduced (1997 dollars) (SCAQMD, 1997).

Cost Effectiveness: The cost effectiveness is estimated to be \$1,248 per ton VOC reduced (1990\$) (SCAQMD, 1997).

Comments:

Status: Demonstrated

Last Reviewed: 1997

AT-A-GLANCE TABLE FOR AREA SOURCES

Additional Information:

Rule 1122 applies to both batch and conveyorized degreasing. The latest amendments, from 1997, set lower VOC limits for batch loaded and conveyorized cold cleaners at 50 grams of VOC per liter of material (SCAQMD, 1997).

Open-top vapor degreasers include a tank for holding the solvent and a heating system to heat and vaporize the liquid solvent. As the liquid solvent vaporizes, a vapor layer is formed above the liquid solvent. The cleaning action is provided by the solvent vapor condensing on the cooler (dirty) parts and either dissolving or flushing contaminants from the parts. The cleaning operation is complete when the temperature of the parts reaches that of the vapor, thereby ending the condensation process (SCAQMD, 1996). The soiled solvent is periodically removed and replaced with fresh solvent.

References:

SCAQMD, 1996: South Coast Air Quality Management District, "1997 Air Quality Management Plan - Appendix IV-A: Stationary and Mobile Source Control Measures," August 1996.

SCAQMD, 1997: South Coast Air Quality Management District, Draft Staff Report for Proposed Amendments to Rule 1122 - Solvent Degreasers, June 3, 1997.

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Open Top Degreasing

Control Measure Name: Airtight Degreasing System

Rule Name: Not Applicable

Pechan Measure Code: V23203

POD: 232

Application: An airtight degreasing unit provides an enclosed environment from which no VOCs can escape.

Emissions for this source category are classified under several area source SCCs beginning with "2415".

Affected SCC:

2415100000 All Industries: Open Top Degreasing, Total: All Solvent Types
2415105000 Furniture and Fixtures (SIC 25): Open Top Degreasing, Total: All Solvent Types
2415110000 Primary Metal Industries (SIC 33): Open Top Degreasing, Total: All Solvent Types
2415120000 Fabricated Metal Products (SIC 34): Open Top Degreasing, Total: All Solvent Types
2415125000 Industrial Machinery & Equipment (SIC 35)-Open Top Degreasing, Total- All Solvents
2415130000 Electronic and Other Elec. (SIC 36): Open Top Degreasing, Total: All Solvent Types
2415135000 Transportation Equipment (SIC 37): Open Top Degreasing, Total: All Solvent Types
2415140000 Instruments & Related Products (SIC 38)-Open Top Degreasing, Total-All Solvents
2415145000 Miscellaneous Manufacturing (SIC 39): Open Top Degreasing, Total: All Solvent Types

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
						√*				

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 98% from uncontrolled

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: In the study to amend Rule 1122, the SCAQMD examined this more stringent control option that requires airless batch cleaning systems or air-tight cleaning systems. This would reduce emissions by a total of 98 percent. The incremental cost effectiveness was taken from the study to amend SCAQMD Rule 1122, estimated to be \$53,360 per ton (beyond the amended rule). (SCAQMD, 1997)

Note: All costs are in 1990 dollars.

Cost Effectiveness: The cost effectiveness is estimated to be \$9,789 per ton VOC reduced (1990\$) (SCAQMD, 1997).

Comments:

Status: Demonstrated

Last Reviewed: 1997

Additional Information:

Additional research is needed to determine the fixed versus recurring cost breakout for open top degreasing control regulations. In general, if new degreasing agents are used, little or no capital expenditures would be required. For the more stringent options such as this one, new equipment is

AT-A-GLANCE TABLE FOR AREA SOURCES

required.

Open-top vapor degreasers include a tank for holding the solvent and a heating system to heat and vaporize the liquid solvent. As the liquid solvent vaporizes, a vapor layer is formed above the liquid solvent. The cleaning action is provided by the solvent vapor condensing on the cooler (dirty) parts and either dissolving or flushing contaminants from the parts. The cleaning operation is complete when the temperature of the parts reaches that of the vapor, thereby ending the condensation process (SCAQMD, 1996). The soiled solvent is periodically removed and replaced with fresh solvent.

References:

SCAQMD, 1996: South Coast Air Quality Management District. "1997 Air Quality Management Plan - Appendix IV-A. Stationary and Mobile Source Control Measures," August 1996.

SCAQMD, 1997: South Coast Air Quality Management District, "Draft Staff Report for Proposed Amendments to Rule 1122 - Solvent Degreasers," June 1997.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Paper and other Web Coating Operations

Control Measure Name: Permanent Total Enclosure (PTE)

Rule Name: Not Applicable

Pechan Measure Code: V40205

POD: 205

Application: A PTE is an enclosure used to surround a source of emissions so that all, or nearly all, emissions are captured and contained, usually for discharge to a control device. The paper and other web coating category includes the surface coating of pressure-sensitive tapes and labels, photographic film, industrial and decorative laminates, flexible vinyl products, flexible packaging, abrasive products and folding paperboard boxes. The EPA evaluated VOC emission control options for the paper and other web coating industry including the use of a PTE in conjunction with a regenerative thermal oxidizer in the MACT standard-setting process for this source category.

Affected SCC:

30701199 Pulp and Paper and Wood Products, Paper Coating and Glazing, Extrusion Coating Line with Solvent Free Resin/Wax

40201301 Surface Coating Operations, Paper Coating, Coating Operation

40201303 Surface Coating Operations, Paper Coating, Coating Mixing

40201304 Surface Coating Operations, Paper Coating, Coating Storage

40201305 Surface Coating Operations, Paper Coating, Equipment Cleanup

40201310 Surface Coating Operations, Paper Coating, Coating Application: Knife Coater

40201320 Surface Coating Operations, Paper Coating, Coating Application: Reverse Roll Coater

40201330 Surface Coating Operations, Paper Coating, Coating Application: Rotogravure Printer

40201399 Surface Coating Operations, Paper Coating, Other Not Classified

40202201 Surface Coating Operations, Plastic Parts, Coating Operation

40202202 Surface Coating Operations, Plastic Parts, Cleaning/Pretreatment

40202203 Surface Coating Operations, Plastic Parts, Coating Mixing

40202204 Surface Coating Operations, Plastic Parts, Coating Storage

40202205 Surface Coating Operations, Plastic Parts, Equipment Cleanup

40202206 Surface Coating Operations, Plastic Parts, Business: Baseline Coating Mix

40202207 Surface Coating Operations, Plastic Parts, Business: Low Solids Solvent-borne Coating

40202208 Surface Coating Operations, Plastic Parts, Business: Medium Solids Solvent-borne Coating

40202209 Surface Coating Operations, Plastic Parts, Business: High Solids Coating (25% Efficiency)

40202210 Surface Coating Operations, Plastic Parts, Business: High Solids Solvent-borne Coating (40% Efficiency)

40202211 Surface Coating Operations, Plastic Parts, Business: Water-borne Coating

40202212 Surface Coating Operations, Plastic Parts, Business: Low Solids Solvent-borne EMI/RFI Shielding Coating

40202213 Surface Coating Operations, Plastic Parts, Business: Higher Solids Solvent-borne EMI/RFI Shielding Coating

40202214 Surface Coating Operations, Plastic Parts, Business: Water-borne EMI/RFI Shielding Coating

40202215 Surface Coating Operations, Plastic Parts, Business: Zinc Arc Spray

40202220 Surface Coating Operations, Plastic Parts, Prime Coat Application

40202229 Surface Coating Operations, Plastic Parts, Prime Coat Flashoff

40202230 Surface Coating Operations, Plastic Parts, Color Coat Application

40202239 Surface Coating Operations, Plastic Parts, Color Coat Flashoff

40202240 Surface Coating Operations, Plastic Parts, Topcoat/Texture Coat Application

AT-A-GLANCE TABLE FOR POINT SOURCES

40202249 Surface Coating Operations, Plastic Parts, Topcoat/Texture Coat Flashoff
40202250 Surface Coating Operations, Plastic Parts, EMI/RFI Shielding Coat Application
40202259 Surface Coating Operations, Plastic Parts, EMI/RFI Shielding Coat Flashoff
40202270 Surface Coating Operations, Plastic Parts, Sanding/Grit Blasting Prior to EMI/RFI Shielding Coat Application
40202280 Surface Coating Operations, Plastic Parts, Maskant Application
40202299 Surface Coating Operations, Plastic Parts, Other Not Classified
31605001 Photographic Film Manufacturing, Product Manufacturing - Surface Treatments, Surface Coating Operations
31616004 Photographic Film Manufacturing, Support Activities - Other Operations, Paint Spraying Operations

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
						√*				

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 95% from uncontrolled

Equipment Life: 30 years (PTE); 10 years (thermal oxidizer)

Rule Effectiveness: 100% for point and area sources

Penetration: 100%

Cost Basis: The cost analysis is based on an average of PTE and oxidizer capital and operating and maintenance costs developed for five model rotogravure printing plants evaluated by EPA for the Paper and Other Web Coating MACT standard (40 CFR Part 63 Subpart JJJJ). Consistent with the OAQPS Control Cost Manual, an interest rate of 7% was used to determine the capital recovery factor. Although the PTE is expected to have a life of 30 years, PTE costs were annualized over a 10 year period (the expected life of the thermal oxidizer). Each PTE was assumed to capture 100% of all VOC emissions. All captured emissions were assumed to be vented to a regenerative thermal oxidizer having a 95% control efficiency. Therefore, the net VOC control efficiency is 95%. Year 1998 dollars were specified for cost calculations in the EPA background document for the paper and other web coating industry.

Cost Effectiveness: The cost effectiveness is \$1,503 per ton VOC reduction (1998\$). The cost effectiveness is based on an annualized capital cost of \$659,351 and an annual operation and maintenance (O&M) cost of \$671,167 averaged over two model paper and other web printing plants.

Comments:

Status: Demonstrated

Last Reviewed: 2004

Additional Information:

References:

EPA, 2000: U.S. Environmental Protection Agency, "National Emission Standards for Hazardous Air Pollutants for Source Categories: Paper and Other Web Coating Operations -- Background Information for Proposed Standards", April 2000.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual", Sixth Edition, document EPA/452/B-02-001, January 2002.

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Paper Surface Coating

Control Measure Name: Incineration

Rule Name: Not Applicable

Pechan Measure Code: V24001

POD: 240

Application: This is a generic control measure based on the use of incineration to reduce VOC emissions from paper coating processes

Area source VOC emissions for the paper coating source category are classified under SCCs 2401030000.

Affected SCC:

2401030000 Paper: SIC 26, Total: All Solvent Types

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
						√/*				

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 78% from uncontrolled

Equipment Life: Not Applicable

Rule Effectiveness: 80%

Penetration: 100%

Cost Basis: Pechan estimated the costs based on estimates for VOC reduction under the Post-CAAA scenarios (Pechan, 1998).

Cost Effectiveness: A cost effectiveness of \$4,776 per ton VOC reduced is used in AirControlNET (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 1998

Additional Information:

References:

Pechan, 1998: E.H. Pechan & Associates, "Clean Air Act Section 812 Prospective Cost Analysis - Draft Report," prepared for U.S. Environmental Protection Agency, September 1998.

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Pesticide Application

Control Measure Name: Reformulation - FIP Rule

Rule Name: California Federal Implementation Plan Rule (Reformulation)

Pechan Measure Code: V29502

POD: 295

Application: The California Federal Implementation Plan (FIP) rule intends to reach the VOC limits by switching to and/or encouraging the use of low-VOC pesticides and better Integrated Pest Management (IPM) practices.

All types of pesticide applications are affected by this rule.

Affected SCC:

2461800000 Pesticide Application: All Processes, Total: All Solvent Types

2461850000 Pesticide Application: Agricultural, All Processes

2465800000 Pesticide Application, Total: All Solvent Types

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
						√*				

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 20% from uncontrolled

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The California Federal Implementation Plan (FIP) Rule is the basis for estimating emission reductions and costs for pesticide application.

Annualized costs resulting from this rule include those associated with:

VOC content analysis required of all pesticide producers = \$6,000,000,

New studies to support reformulation of restricted pesticides = \$408,000,000

Registration fees of reformulated products = \$556,000,000

The CA FIP estimated the cost effectiveness for a 20 percent reduction to be \$9,300 per ton based on the above annualized costs and an emissions reduction of 157 tons per day (Radian, 1994). This cost is likely overestimated given the information available from California's Department of Pesticide Regulation; however, no new cost effectiveness estimates are available to date.

Cost Effectiveness: The cost effectiveness per ton VOC reduced is \$9,300 (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 1999

Additional Information:

CARB formed the Department of Pesticide Regulation (DPR) in 1991 to regulate all aspects of pesticide sales and use. The DPR has implemented a faster registration process so that new pesticide products can be more quickly integrated. The DPR also encourages better IPM practices

AT-A-GLANCE TABLE FOR AREA SOURCES

by working with local agricultural agencies and rewarding those who demonstrate good practice or innovation.

No new regulations have been developed for pesticides as the DPR believes that the reduction goals will be met through reformulation (which is occurring without specific air regulations) and better IPM practices (CDPR, 1999).

References:

CDPR, 1999: California Department of Pesticide Regulation website: www.cdpr.ca.gov.

Radian, 1994: Radian Corporation, "Technical Support Document: Proposed FIP Pesticides Measure 52.2960," prepared for the U.S. Environmental Protection Agency, February 1994.

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Portable Gasoline Containers

Control Measure Name: OTC Portable Gas Container Rule

Rule Name: OTC Portable Gas Container Rule

Pechan Measure Code: V24605

POD: 305

Application: The rule specifies performance standards for portable fuel containers and/or spouts which are intended to reduce emissions from storage, transport and refueling activities. The rule states that any portable fuel container and/or spout must provide the following:

- ☐ Only one opening for both filling and pouring;
- ☐ An automatic shut-off to prevent overfill during refueling;
- ☐ Automatic closing and sealing of the container and/or spout when not dispensing fuel;
- ☐ A fuel flow rate and fill level as specified in the rule;
- ☐ A permeation rate of less than or equal to 0.4 grams per gallon per day; and
- ☐ A warranty by the manufacturer as specified in the rule.

Affected SCC:

2501000120: Storage and Transport: Petroleum and Petroleum Product Storage: All Storage Types: Breathing Loss: Gasoline

2501010120: Storage and Transport: Petroleum and Petroleum Product Storage: Commercial/Industrial: Breathing Loss: Gasoline

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
						√*				

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 33% from uncontrolled

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The annual gas can population turnover and the estimated sales process for each container are used to calculate the incremental cost of the draft model rule on an annual basis. The total VOC reductions for 2007 and the annual incremental cost were used to calculate cost of compliance in dollars per ton.

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$581 per ton VOC reduced (1999\$).

Comments:

Status:

Last Reviewed: 2005

Additional Information:

References:

Pechan 2001: E.H. Pechan & Associates, Inc., "Control Measure Development Support – Analysis of Ozone Transport Commission Model Rules," prepared for Ozone Transport Commission, March, 2001.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Product and Packaging Rotogravure and Screen Printing

Control Measure Name: Permanent Total Enclosure (PTE)

Rule Name: Not Applicable

Pechan Measure Code: V40206

POD: 206

Application: A PTE is an enclosure used to surround a source of emissions so that all, or nearly all, emissions are captured and contained, usually for discharge to a control device. Product and packaging rotogravure includes folding cartons, flexible packaging, labels and wrappers, gift wraps, wall coverings, vinyl printing, decorative laminates, floor coverings, tissue products and miscellaneous specialty products such as cigarette tipping paper. The EPA evaluated VOC emission control options for the publication rotogravure printing industry including the use of a PTE in conjunction with a solvent concentrator in the MACT standard-setting process for this source category. Rotary screen printing is sometimes used in combination with product and packaging rotogravure printing.

Affected SCC:

2425030000 Graphic Arts, Rotogravure, Total: All Solvent Types

40201330 Surface Coating Operations, Paper Coating, Coating Application: Rotogravure Printer

40500801 Printing/Publishing, General, Screen Printing

40500811 Printing/Publishing, General, Screen Printing

40500811 Printing/Publishing, General, Screen Printing

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
						√*				

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 96.4% from uncontrolled

Equipment Life: 30 years (PTE); 15 years (thermal oxidizer)

Rule Effectiveness: 100% for point and area sources

Penetration: 100%

Cost Basis: The cost analysis is based on an average of PTE and oxidizer capital and operating and maintenance costs developed for five model product and packaging rotogravure printing plants evaluated by EPA for the Printing and Publishing MACT standard (40 CFR Part 63 Subpart KK). Consistent with the OAQPS Control Cost Manual, an interest rate of 7% was used to determine the capital recovery factor. Each PTE was assumed to capture 100% of all VOC emissions. All captured emissions were assumed to be vented to a thermal oxidizer having an average 96.4% control efficiency (average for all five model plants evaluated). Therefore, the net VOC control efficiency is 96.4%. Year 1993 dollars were specified for cost calculations in the EPA background document for the printing and publishing industry. In many cases, catalytic incineration is appropriate for solvents used in product and packaging rotogravure; in these cases, catalytic incineration systems would have lower operating costs.

Cost Effectiveness: The cost effectiveness is \$12,770 per ton VOC reduction (1993\$). The cost effectiveness is based on an annualized capital cost of \$93,552 and an annual operation and maintenance (O&M) cost of \$999,932 averaged over five model

AT-A-GLANCE TABLE FOR POINT SOURCES

packaging and product rotogravure printing plants.

Comments:

Status: Demonstrated	Last Reviewed: 2004
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Additional Information:

References:

EPA, 1995: U.S. Environmental Protection Agency, "National Emission Standards for Hazardous Air Pollutants: Printing and Publishing Industry Background Information for Proposed Standards", February 1995.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual", Sixth Edition, document EPA/452/B-02-001, January 2002.

AT-A-GLANCE TABLE FOR POINT SOURCES

Source Category: Publication Rotogravure Printing

Control Measure Name: Permanent Total Enclosure (PTE)

Rule Name: Not Applicable

Pechan Measure Code: V40207

POD: 207

Application: A PTE is an enclosure used to surround a source of emissions so that all, or nearly all, emissions are captured and contained, usually for discharge to a control device. Publication rotogravure primarily involves the printing of newspapers, magazines, and advertisement inserts. The EPA evaluated VOC emission control options for the rotogravure printing industry, including the use of a PTE in conjunction with a solvent concentrator in the MACT standard-setting process for this source category.

Affected SCC:

2425030000 Graphic Arts, Rotogravure, Total: All Solvent Types

40201330 Surface Coating Operations, Paper Coating, Coating Application: Rotogravure Printer

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
						√*				

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 95% from uncontrolled

Equipment Life: 30 years (PTE); 15 years (thermal oxidizer)

Rule Effectiveness: 100% for point and area sources

Penetration: 100%

Cost Basis: The cost analysis is based on an average of PTE and oxidizer capital and operating and maintenance costs developed for five model publication rotogravure printing plants evaluated by EPA for the Printing and Publishing MACT standard (40 CFR Part 63 Subpart KK). Consistent with the OAQPS Control Cost Manual, an interest rate of 7% was used to determine the capital recovery factor. Although the PTE is expected to have a life of 30 years, PTE costs were annualized over a 15 year life (the expected life of the solvent concentrator). Each PTE was assumed to capture 100% of all VOC emissions. All captured emissions were assumed to be vented to a solvent concentrator having a 95% control efficiency (average for all five concentrators evaluated). Therefore, the net VOC control efficiency is 95%. Year 1993 dollars were specified for cost calculations in the EPA background document for the printing and publishing industry.

Cost Effectiveness: The cost effectiveness is \$2,422 per ton VOC reduction (1993\$). The cost effectiveness is based on an annualized capital cost of \$520,781 and an annual operation and maintenance (O&M) cost of \$603,344 averaged over five model publication rotogravure printing plants.

Comments:

Status: Demonstrated

Last Reviewed: 2004

Additional Information:

AT-A-GLANCE TABLE FOR POINT SOURCES

References:

EPA, 1995: U.S. Environmental Protection Agency, "National Emission Standards for Hazardous Air Pollutants: Printing and Publishing Industry Background Information for Proposed Standards", February 1995.

EPA, 2002: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "EPA Air Pollution Control Cost Manual", Sixth Edition, document EPA/452/B-02-001, January 2002

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Rubber and Plastics Manufacturing

Control Measure Name: SCAQMD - Low VOC

Rule Name: South Coast Air Quality Management District Rule 1145 - Plastic, Rubber and Glass Coatings

Pechan Measure Code: V24401

POD: 244

Application: SCAQMD Rule 1145 - Plastic, Rubber, and Glass Coatings was adopted to reduce VOC emissions from plastic, rubber, and glass operations. Since its adoption, this rule has been amended numerous times incorporating more stringent VOC limits as the technology and low VOC coatings have become available. The last amendment in March 1996 was to exempt aerosol coatings and to provide rule consistency with the recently adopted ARB Aerosol Coating Products Rule.

There are a variety of control methods to reduce VOCs from plastic, rubber, and glass coatings operations. VOC emissions can be reduced by using reformulated low-VOC content compliant coatings, UV curable coatings, high transfer efficiency coating applications and increased effectiveness of add-on control equipment.

Affected SCC:

2430000000 All Processes, Total: All Solvent Types

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
						√*				

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 60% from uncontrolled

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The cost estimates are based on studies done in the development and amendment of the SCAQMD Rule 1145 (SCAQMD, 1996). The rule is estimated to reduce emissions from rubber and plastics manufacturing by 60%, with an expected cost effectiveness of \$1,020 per ton VOC reduced (1990 dollars) (SCAQMD, 1996).

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$1,020 per ton VOC reduced (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 1996

Additional Information:

The majority of VOC emissions from this source category are generated from coating, cleaning, and other manufacturing operations used in the production of plastic, rubber and glass substrates. Glass products manufactured in the South Coast Basin are primarily mirrors (SCAQMD, 1996). During the coating application process for mirrors, glass is passed under a flow coater or roll coater. The coating or product is either forced-dried or air-dried. Molded or formed glass objects can be either dipped or sprayed.

AT-A-GLANCE TABLE FOR AREA SOURCES

Rubber products are typically spray painted. Artistic designs are applied to the substrate through a mask or by using transfer decals. Adding pigment to the rubber during its manufacturing can avoid the need for painting.

Plastic products use the widest variety of coating application techniques. The majority of coatings are sprayed, but dip coating, flow coating, and roller coating are also used. Coatings are typically air-dried or forced-dried, because excess heat can cause them to melt and deform. Masks are used to manufacture toys and multicolored products. Coatings may be eliminated by using colored plastic or transfer decals. Letters, numbers, and designs may be transferred to an object by a process similar to a letter press.

References:

SCAQMD, 1996: South Coast Air Quality Management District. "1997 Air Quality Management Plan - Appendix IV-A. Stationary and Mobile Source Control Measures," August 1996.

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Stage II Service Stations

Control Measure Name: Low Pressure/Vacuum Relief Valve

Rule Name: Not Applicable

Pechan Measure Code: V30101

POD: 301

Application: This control measure is the addition of low pressure/vacuum (LP/V) relief valves to gasoline storage tanks at service stations with Stage II control systems. LP/V relief valves prevent breathing emissions from gasoline storage tank vent pipes.

This control measure applies to all gasoline service stations with Stage II control systems, classified under SCC 2501060100.

Affected SCC:

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
						√*				

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 92% from uncontrolled

Equipment Life: 10 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The cost for this rule were estimated by the SCAQMD. They estimated the cost effectiveness based on the following assumptions:

6% of stations already have LP/V valves;
stations without LP/V valves need an average of 3 valves;
the valves can be installed with one hour of labor;
each valve costs \$57; and
the installation is paid for over 10 years at 4% interest (SCAQMD, 1995).

Note: All costs are in 1994 dollars.

Cost Effectiveness: The annual cost per ton VOC reduced used in AirControlNET is \$1,080. (1991\$)

EPA estimated the cost effectiveness to range from \$930 to \$1,230 per ton VOC removed depending on whether or not small service stations were exempted (EPA, 1995).

Comments:

Status: Demonstrated

Last Reviewed: 1999

AT-A-GLANCE TABLE FOR AREA SOURCES

Additional Information:

Stage II vapor recovery systems utilize a dispensing nozzle and attached hose to collect and return the displaced gasoline vapors from the vehicle fuel tank back to the storage tank. Stage II systems work effectively with a variety of vehicle fill pipes, unlike Stage I systems. The Stage II system will have either a tubular bellows, or "boot," or a face cone to recover VOC emissions from the fueling process (SCAQMD, 1995).

References:

EPA, 1995: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stage II Comparability Study for the Northeast Ozone Transport Region," Research Triangle Park, NC, January 1995.

SCAQMD, 1995: South Coast Air Quality Management District, "Staff Report for: Proposed Amendments to Rule 461 - Gasoline Transfer and Dispensing," August 1995.

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Stage II Service Stations - Underground Tanks

Control Measure Name: Low Pressure/Vacuum Relief Valve

Rule Name: Not Applicable

Pechan Measure Code: V30201

POD: 302

Application: This control measure is the addition of low pressure/vacuum (LP/V) relief valves to underground gasoline storage tanks at service stations with Stage II control systems. LP/V relief valves prevent breathing emissions from gasoline storage tank vent pipes.

This control measure applies to all gasoline service stations with underground gasoline storage tanks, classified under SCC 2501060201.

Affected SCC:

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
						√*				

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 73% from uncontrolled

Equipment Life: 10 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The cost for this rule were estimated by the SCAQMD. They estimated the cost effectiveness based on the following assumptions:

6% of stations already have LP/V valves;
stations without LP/V valves need an average of 3 valves;
the valves can be installed with one hour of labor;
each valve costs \$57; and
the installation is paid for over 10 years at 4% interest (SCAQMD, 1995).

Note: All costs are in 1994 dollars.

Cost Effectiveness: The annual cost per ton VOC reduced used in AirControlNET is \$1,080. (1991\$)

EPA estimated the cost effectiveness to range from \$930 to \$1,230 per ton VOC removed depending on whether or not small service stations were exempted (EPA, 1995).

Comments:

Status: Demonstrated

Last Reviewed: 1999

AT-A-GLANCE TABLE FOR AREA SOURCES

Additional Information:

Stage II vapor recovery systems utilize a dispensing nozzle and attached hose to collect and return the displaced gasoline vapors from the vehicle fuel tank back to the storage tank. Stage II systems work effectively with a variety of vehicle fill pipes, unlike Stage I systems. The Stage II system will have either a tubular bellows, or "boot," or a face cone to recover VOC emissions from the fueling process (SCAQMD, 1995).

References:

EPA, 1995: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Stage II Comparability Study for the Northeast Ozone Transport Region," Research Triangle Park, NC, January 1995.

SCAQMD, 1995: South Coast Air Quality Management District, "Staff Report for: Proposed Amendments to Rule 461 - Gasoline Transfer and Dispensing," August 1995.

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Traffic Markings

Control Measure Name: AIM Coating Federal Rule

Rule Name: Architectural and Industrial Maintenance Coatings Federal Rule

Pechan Measure Code: V22101

POD: 221

Application: This federal rule provides uniformity over the state-level content limits that AIM coating manufacturers must meet. The rule sets maximum allowable VOC content limits for 55 different categories of AIM coatings, and affects the manufacturers and importers of the coating products. VOC content limits defined in the national rule took effect on September 11, 1999. Manufacturers of FIFRA - regulated coatings had until March 10, 2000 to comply.

Sixty-four percent of the products included in the 1990 industry survey meet the VOC content limits in this rule and, therefore, there will be no costs to reformulate these products. The manufacturer of a product that does not meet the VOC content limits will be required to reformulate the product if it will continue to be marketed, unless the manufacturer chooses to use an alternative compliance option such as the exceedance fee or tonnage exemption provision.

In AirControlNET, this specific control measure applies only to traffic markings.

Affected SCC:

2401008000 Traffic Markings, Total: All Solvent Types

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
						√*				

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 20% from uncontrolled

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The cost estimates are based upon information provided to EPA by industry representatives during the regulatory negotiation process. Industry representatives estimated the level of effort required by a representative firm to research and develop a new prototype coating to be 2.5 scientist-years over a 3-year time period. EPA calculated an annualized cost of \$17,772 per reformulation (1991 dollars) based on an assumed cost of \$100,000 per scientist-year as amortized over an assumed repopulation cycle of 2.5 years.

The estimated average cost to reformulate a product was \$87,000. The total estimated national cost of the AIM Coating Federal rule is 25.6 million per year (1991 dollars).

Cost Effectiveness: EPA estimated emission reductions of 106,000 tons of VOC per year so that the cost effectiveness is computed as \$228 per ton VOC reduction (1990\$)..

Comments: The EPA did not account for potential cost differences for reformulating coatings to

AT-A-GLANCE TABLE FOR AREA SOURCES

various content limits. Instead, EPA assumed that a reformulation has a certain cost to manufacturers regardless of the target content limit, or the anticipated VOC reduction (Ducey, 1997).

Status: Demonstrated

Last Reviewed: 1997

Additional Information:

In its analysis of the proposed federal rule, EPA assumed that the cost of product reformulation would bring the VOC content limit for each noncompliant coating down to the level of the standards. The EPA, however, noted the likelihood that some manufacturers will likely reduce the VOC content of their coatings to levels significantly below the limits in the rule (EPA, 1996). The at-the-limit assumption, therefore, likely results in emission reductions being understated. In its cost analysis, insufficient data were available for EPA to distinguish reformulation costs between different coating types (i.e., the reformulation cost for flat paints is equal to the reformulation cost for all other affected paint types). The EPA noted the likelihood of reformulation costs varying from product to product (EPA, 1995).

References:

Ducey, 1997: E. Ducey, U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, personal communication with D. Crocker, E.H. Pechan & Associates, Inc., February 13, 1997.

EPA, 1995: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "Economic Impact and Regulatory Flexibility Analysis of the Proposed Architectural Coatings Federal Rule," Research Triangle Park, NC, March 1995.

EPA, 1996: U.S. Environmental Protection Agency, Emission Standards Division, Office of Air and Radiation, "Architectural Coatings - Background for Proposed Standards, Draft Report," March 1996.

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Traffic Markings

Control Measure Name: South Coast Phase I

Rule Name: South Coast AQMD Rule 1113 - Architectural Coatings

Pechan Measure Code: V22102

POD: 221

Application: The Phase I rule is an amendment to SCAQMD's existing architectural coatings rule that establishes more stringent VOC content limits for flat, multi-color, traffic, and lacquer coatings. These VOC limits in the SCAQMD for multi-color, traffic, and lacquer coatings took effect on January 1, 1998, while the Phase I limits for flat coating took effect on January 1, 2001.

Reductions in VOC emissions from these coatings are achieved through the use of product reformulation and product substitution.

Affected SCC:

2401008000 Traffic Markings, Total: All Solvent Types

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
						√*				

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 34% from uncontrolled

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: For the Phase I amendment, a SCAQMD report documents cost per gallon, total annual cost, emission reduction and cost-effectiveness values for each of the four regulated coating types (SCAQMD, 1996).

The SCAQMD estimated that manufacturers would use an acetone formulation with an associated cost of \$2 per gallon to meet the proposed 550 grams per liter (g/L) VOC limit for lacquers. For flats, South Coast estimated a zero cost for complying with the near-term 100 g/L limit since most flats sold in California are already in compliance with this limit. For traffic and multi-color coatings, the SCAQMD estimated that a cost savings was likely to be associated with reformulation due to a decrease in the cost of input materials. (The estimated magnitude of the savings is not documented in the SCAQMD report.)

Costs were estimated by multiplying the cost per gallon data to total gallons sold. The resulting weighted average cost effectiveness value was converted to 1990 dollars using the 1995:1990 producer price index for Standard Industrial Classification (SIC) code 2851 (Paints and Allied Products).

Because capital cost information was not available, capital costs were not estimated for this analysis.

Cost Effectiveness: CARB indicated that costs ranged from a savings of \$8,600 per ton (for pool

AT-A-GLANCE TABLE FOR AREA SOURCES

finishes) to cost of \$12,800 per ton of VOC reduced (for specialty enamels) (CARB, 1989). The cost effectiveness range is attributable to the wide diversity of coatings.

AirControlNET uses a cost effectiveness of \$1,443 per ton VOC reduction based on a weighted average of national sales data by coating type (EPA, 1996) (1990\$).

Comments:

Status: Demonstrated	Last Reviewed: 1996
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Additional Information:

References:

CARB, 1989: California Air Resources Board, Stationary Source Division, "ARB-CAPCOA Suggested Control Measure for Architectural Coatings, Technical Support Document," July 1989.

EPA, 1996: U.S. Environmental Protection Agency, Emission Standards Division, Office of Air and Radiation, "Architectural Coatings - Background for Proposed Standards, Draft Report," EPA-453/R-95-009a, March 1996.

SCAQMD, 1996: South Coast Air Quality Management District, "Proposed Modifications to the Appendices of the Draft 1997 Air Quality Management Plan," October 1996.

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Traffic Markings

Control Measure Name: South Coast Phase II

Rule Name: South Coast AQMD Rule 1113 - Architectural Coatings

Pechan Measure Code: V22103

POD: 221

Application: Phase II represents an effort to lower the VOC content limits for non-flat industrial maintenance primers and topcoats, sealers, undercoaters, and quick-dry enamels. The rule requires manufacturers of the coatings sold in the SCAQMD to meet the VOC limit requirements provided in the rule between 2002 and 2006.

Reductions in VOC emissions from these coatings are achieved through the use of product reformulation and product substitution.

Affected SCC:

2401008000 Traffic Markings, Total: All Solvent Types

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
						√*				

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 47% from uncontrolled

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: For the Phase II amendments, the SCAQMD completed a socioeconomic impact assessment (SCAQMD, 1999). SCAQMD assumed a 10 percent price increase per gallon for compliant coatings meeting Phase II and estimated the cost based on the number of gallons produced. Costs vary significantly among individual coatings categories.

Because capital cost information was not available, capital costs were not estimated for this analysis.

Cost Effectiveness: AirControlNET uses a cost effectiveness of \$4,017 per ton VOC reduction (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 1996

Additional Information:

The South Coast notes that the process of collecting reformulation cost data for these categories is very complex due to the resin technology used in lower-VOC, high-performance industrial maintenance coatings (silicon-based resins, or polyurethanes) and the number of resin systems involved (Berry, 1997).

AT-A-GLANCE TABLE FOR AREA SOURCES

References:

Berry, 1997: N. Berry, South Coast Air Quality Management District, personal communication with D. Crocker, E.H. Pechan & Associates, Inc., March 4, 1997.

SCAQMD, 1999: South Coast Air Quality Management District, "Addendum to Staff Report: Final Socioeconomic Impact Assessment, Proposed Amendments to Rule 1113," May 1999.

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Traffic Markings

Control Measure Name: South Coast Phase III

Rule Name: South Coast AQMD Rule 1113 - Architectural Coatings

Pechan Measure Code: V22104

POD: 221

Application: Phase III applies to additional consumer products that are not affected by Phase I or II. The rule requires manufacturers to limit VOC content of the specified coatings sold in the SCAQMD using a phased-in approach specifying compliance dates that depend on the coating type. Compliance dates range from 1/1/03 to 7/1/08.

Reductions in VOC emissions from these coatings are achieved through the use of product reformulation and product substitution.

In AirControlNET this measure only applies to traffic markings.

Affected SCC:

2401008000 Traffic Markings, Total: All Solvent Types

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
						√*				

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 73% from uncontrolled

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: SCAQMD has not yet estimated the costs for implementing the Phase III limits at the time this control was developed. As an estimate, Pechan uses the highest incremental cost effectiveness estimate for any individual product for the Phase II amendments of \$26,000 per ton (1998 dollars). This value is about double the average of Phase II products. This cost estimate is highly uncertain as no specific cost data are available (Pechan, 1999).

Because capital cost information was not available, capital costs were not estimated for this analysis.

Cost Effectiveness: AirControlNET uses an overall cost effectiveness of \$10,059 per ton VOC reduction (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 1996

Additional Information:

The Phase III controls apply to additional consumer products that are not affected by the near-term measures. These measures, which are expected to take effect between 2000 and 2005, are expected to result in an additional 25 percent VOC reduction from consumer products.

AT-A-GLANCE TABLE FOR AREA SOURCES

References:

Pechan, 1999: E.H. Pechan & Associates, Inc., "Control Measure Evaluations: The Control Measure Data Base For the National Emission Trends Inventory (AirControlNET)," prepared for the U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, 1999.

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Wood Furniture Surface Coating

Control Measure Name: MACT Standard

Rule Name: Maximum Achievable Control Technology for Wood Furniture Surface Coating

Pechan Measure Code: V22501

POD: 225

Application: The MACT establishes emission limits for finishing materials, adhesives, and strippable spray booth coatings. It also specifies work practices that minimize evaporative emissions from the storage, transfer, and application of coatings and solvents. The MACT standard for wood furniture surface coatings allows facilities to use one of the following methods to demonstrate compliance: compliant coatings; averaging; an add-on control device; a combination of compliant coatings and an add-on control device; or a combination of an add-on control device and averaging.

The rule affects the production of the following products and their components: wood kitchen cabinets; wood residential furniture, upholstered residential and office furniture; wood television, radio, phonograph, and sewing machine cabinets; wood office furniture and fixtures; partitions, shelving and lockers; and other wood furniture.

Affected SCC:

2401020000 Wood Furniture: SIC 25, Total: All Solvent Types

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
						√/*				

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 30% from uncontrolled

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: EPA estimates the costs using a model plant approach. The total cost estimate includes the costs of incineration, spray guns, and carbon adsorption as control options. For gluing operations, capital costs include the cost for drying ovens and delivery systems. (Pechan, 1998)

For application to the area sources, the cost-effectiveness is an average of the costs associated with the two smallest model plant size categories:

Small = \$150 per ton VOC reduced

Medium = \$704 per ton VOC reduced

Cost Effectiveness: The cost effectiveness is \$446 per ton VOC reduction (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 1997

Additional Information:

AT-A-GLANCE TABLE FOR AREA SOURCES

References:

Pechan, 1998: E. H. Pechan & Associates, "Emission Projections for the Clean Air Act Section 812 Prospective Analysis," June 1998..

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Wood Furniture Surface Coating

Control Measure Name: New CTG

Rule Name: Not Applicable

Pechan Measure Code: V22502

POD: 225

Application: The new CTG, published in 1996, applies to ozone nonattainment areas and the Ozone Transport Region (OTR). This will affect facilities emitting 25 tons per year or more.

The Wood furniture coating industry covers 10 SIC codes including: Wood Kitchen Cabinets; Wood Household Furniture (except upholstered); Wood Household Furniture (upholstered); Wood Television, Radios, Phonograph, and Sewing Machine Cabinets; Household Furniture Not Classified Elsewhere; Wood Office Furniture; Public Building and Related Furniture; Wood Office and Store Fixtures; Furniture and Fixtures Not Elsewhere Classified; and Custom Kitchen Cabinets. Area source emissions would typically account for the smaller facilities that are not covered in the point source inventory.

Affected SCC:

2401020000 Wood Furniture: SIC 25, Total: All Solvent Types

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
						√*				

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 47% from uncontrolled

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: EPA (1996) estimated the cost effectiveness using a model plant technique for 16 plants. The cost estimates include low-VOC coating costs, application equipment costs, and operator training costs (EPA, 1996).

Cost Effectiveness: The cost effectiveness used in AirControlNET is \$967 per ton VOC reduction (1990\$).

The CTG examined several controls and an overall range from a savings of \$462 to a cost of \$22,100 per ton VOC reduced was estimated.

Comments:

Status: Demonstrated

Last Reviewed: 1999

Additional Information:

References:

EPA, 1996: U.S. Environmental Protection Agency, "Control of Volatile Organic Compound Emissions from Wood Furniture Manufacturing Operations," April 1996.

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Wood Furniture Surface Coating

Control Measure Name: Add-On Controls

Rule Name: Not Applicable

Pechan Measure Code: V22503

POD: 225

Application: This control measure is generic in that it represents potential add-on controls available for this source category. Add-on controls include hybrid waterborne systems, full waterborne systems, other alternative coatings, thermal incinerators, catalytic incinerators, and a combination of carbon absorbers and catalytic incinerators.

This control applies to all wood furniture coating applications.

Affected SCC:

2401020000 Wood Furniture: SIC 25, Total: All Solvent Types

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
						√*				

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 75% from uncontrolled

Equipment Life: 10 years

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The cost is based on estimates for small industrial sources to install add-on control options. The highest costs for add-on controls are associated with specialized and small plants (Pechan, 1999).

The industry sponsored study whose information was included in the guideline document used a 10 percent discount rate in the computation of a capital recovery factor (EPA, 1996).

Cost Effectiveness: Depending on the control, a cost effectiveness range of \$468 per ton to more than \$22,100 per ton VOC reduced is estimated. Emissions reductions range from 67 to 98 percent (Pechan, 1999).

The cost effectiveness used in AirControlNET is \$20,000 per ton VOC reduced (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 1999

Additional Information:

Where facilities can achieve comparable reductions through the use of hybrid waterborne systems, full waterborne systems or other alternative coatings, reductions may be higher and costs may be lower than those estimated based on this add-on control measure. For some of the smallest facilities, add-on controls may not be feasible (Pechan, 1999).

AT-A-GLANCE TABLE FOR AREA SOURCES

There are control options that were evaluated, but not selected, in EPA's estimates of preemptive RACT requirements for this source category.

References:

EPA, 1996: U.S. Environmental Protection Agency, Emission Standards Division, "Control of Volatile Organic Compound Emissions from Wood Furniture Coating Operations," Guideline Series, Research Triangle Park, NC, April, 1996.

Pechan, 1999: E.H. Pechan & Associates, Inc., "Control Measure Evaluations: The Control Measure Data Base For the National Emission Trends Inventory (AirControlNET)," prepared for the U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, 1999.

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Wood Product Surface Coating

Control Measure Name: MACT Standard

Rule Name: Maximum Achievable Control Technology for Wood Product Surface Coating

Pechan Measure Code: V22401

POD: 224

Application: The Wood Product Surface Coating MACT sets emissions limits from wood product surface coating facilities. The proposed rule allows for several compliance options including the use of coatings that have been reformulated to reduce air toxics content, upgrading or installation of new capture-and-control systems to reduce air toxics emissions, or a combination of the two. The final rule was proposed February 2003.

The MACT applies to new, reconstructed, or existing wood building product facilities that use more than 4,170 liters (1,100 gallons) of coatings per year and that are "major" sources of air toxics emissions (EPA, 2002).

Affected SCC:

2401015000 Factory Finished Wood: SIC 2426 thru 242, Total: All Solvent Types

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
						√*				

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 30% from uncontrolled

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: At the time the control measure was developed the MACT had not yet been proposed. Pechan assumed a cost effectiveness of \$446 per ton corresponding to a control efficiency of 30% (Pechan, 1997)

Cost Effectiveness: The cost effectiveness is \$446 per ton VOC reduction (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 1997

Additional Information:

References:

EPA, 2002: U.S. Environmental Protection Agency, "Fact Sheet - Proposed Rule to Reduce Toxic Air Pollutants From Surface Coating of Wood Building Products," May 2002. Retrieved April 29, 2003 from <http://www.epa.gov/ttn/atw/wbldg/wbldgpg.html>.

E.H. Pechan & Associates, Inc., "Integrated Ozone, Particulate Matter, and Regional Haze Cost Analysis - Methodology and Results," prepared for U.S. Environmental Protection Agency, Innovative Strategies and Economics Group, Office of Air Quality Planning and Standards, June 6, 1997.

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Wood Product Surface Coating

Control Measure Name: SCAQMD Rule 1104

Rule Name: South Coast Air Quality Management District Rule 1104 - Wood Flat Stock Coatings Operations

Pechan Measure Code: V22402

POD: 224

Application: The SCAQMD rule 1104 sets VOC content limits for wood product surface coatings. This rule establishes specifications for application and solvent cleaning requirements (SCAQMD, 1999). The amendments to this rule also sets stringent VOC limits for inks and exterior siding coatings.

This rule applies to factory finished wood coatings.

Affected SCC:

2401015000 Factory Finished Wood: SIC 2426 thru 242, Total: All Solvent Types

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
						√/*				

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 53% from uncontrolled

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: SCAQMD estimated costs for this control when developing amendments to rule 1104. Factors affecting cost include product reformulations (SCAQMD, 1996).

The amendments are expected to reduce emissions by 17 percent over current baseline levels at a cost-effectiveness of \$1,802 per ton of VOC reduced (1999 dollars) (SCAQMD, 1999). This results in an overall reduction of 53 percent at an incremental cost of \$1,429 per ton (1990 dollars) for an overall cost per ton VOC reduced of \$881.

Cost Effectiveness: The cost effectiveness is \$881 per ton VOC reduction (1990\$).

Comments:

Status: Demonstrated

Last Reviewed: 1999

Additional Information:

References:

SCAQMD, 1996: South Coast Air Quality Management District, "Proposed Modifications to the Appendices of the Draft 1997 Air Quality Management Plan," October 1996.

SCAQMD, 1999: South Coast Air Quality Management District, "Staff Report: Proposed Amended Rule 1104 - Wood Flat Stock Coating Operations," August 1999.

AT-A-GLANCE TABLE FOR AREA SOURCES

Source Category: Wood Product Surface Coating

Control Measure Name: Incineration

Rule Name: Not Applicable

Pechan Measure Code: V22403

POD: 224

Application: This is a generic control measure based on the use of incineration to reduce VOC emissions from wood coating facilities.

This control measure applies to sources classified as factory finished wood producers, SCC 2401015000.

Affected SCC:

2401015000 Factory Finished Wood: SIC 2426 thru 242, Total: All Solvent Types

Pollutant(s)	PM10	PM2.5	EC	OC	NOx	VOC	SO2	NH3	CO	Hg
						√*				

√ = pollutant reduction; X = pollutant increase, * = major pollutant

Control Efficiency: 86% from uncontrolled

Equipment Life: Not Applicable

Rule Effectiveness: 100%

Penetration: 100%

Cost Basis: The cost analysis is based on SCAQMD alternative control techniques data. For the one facility examined (which has coatings above the proposed limits), cost effectiveness is estimated at \$4,202 per ton reduced (1999 dollars) for a reductions of 86 percent.

Cost Effectiveness: A cost effectiveness of \$4,202 per ton VOC reduced is used in AirControlNET. (1999\$)

Comments:

Status: Demonstrated

Last Reviewed: 1999

Additional Information:

References:

No reference found in Pechan's documentation.

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CHAPTER IV. REFERENCES

- Pechan, 1995: E.H. Pechan & Associates, Inc., “Regional Particulate Strategies,” Draft Report, prepared for U.S. Environmental Protection Agency, Office of Policy Planning and Evaluation, Washington, DC, Pechan Report No. 95.09.005/1754, September 29, 1995.
- Pechan, 1997: E.H. Pechan & Associates, Inc., “Additional Control Measure Evaluation for the Integrated Implementation of the Ozone and Particulate Matter National Ambient Air Quality Standards, and Regional Haze Program,” prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, Pechan Report No. 97.03.001/1800 (Rev.), July 17, 1997.
- Pechan, 1999: E.H. Pechan & Associates, Inc., “Control Measure Evaluations: The Control Measure Data Base for the National Emission Trends Inventory (AirControlNET),” Draft Report, prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, Pechan Report No. 99.09.001/9004.112, September 1999.
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- Pechan, 2001b: E.H. Pechan & Associates, Inc., “Control Measure Development Support Analysis of Ozone Transport Commission Model Rules,” Draft Report, prepared for the Ozone Transport Commission, Washington, DC, Pechan Report No. 01.02.001/9408.000, February 5, 2001.
- Pechan, 2002: E.H. Pechan & Associates, Inc., “VOC and NO_x Control Measures Adopted by States and Nonattainment Areas for 1999 NEI Base Case Emissions Projection Calculations,” Draft Report, prepared for U.S. Environmental Protection Agency, Research Triangle Park, NC, Pechan Report No. 02.09.002/9010.122, September 2002.
- Pechan, 2005a: E.H. Pechan & Associates, Inc., “AirControlNET User’s Guide, Version 4,” Draft Report, prepared for U.S. Environmental Protection Agency, Research Triangle Park, NC, Pechan Report No. 03.05/9010.463, August 2005.
- Pechan, 2005b: E.H. Pechan & Associates, Inc., “AirControlNET Tool Development Report, Version 4, prepared for U.S. Environmental Protection Agency, Research Triangle Park, NC, Pechan Report No. 03.05/9010.463, August 2005.

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APPENDIX A: CONTROL MEASURE SUMMARY LIST - BY SOURCE

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Appendix A Control Measure Summary List by Source Category - Sorted alphabetically by Source Category and SCC

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency			Average Annual Cost Effectiveness		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										(% from baseline)			(\$/ton primary pollutant)		
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg	Low	Typical	High	Low	Typical	High
Adhesives - Industrial	SCAQMD Rule 1168						√*						73%			2,202	
Agricultural Burning	Bale Stack/Propane Burning	√	√*	√	√							49%	63%	63%		2,591	
Agricultural Burning	Seasonal Ban (Ozone Season Daily)					√*							100%			N/A	
Agricultural Tilling	Soil Conservation Plans	√	√	√	√								11.7%			138	
Aircraft Surface Coating	MACT Standard						√*						60%			165	
Ammonia - Natural Gas - Fired Reformers - Small Sources	Low NOx Burner					√*							50%			820	
Ammonia - Natural Gas - Fired Reformers - Small Sources	Low NOx Burner (LNB) + Flue Gas Recirculation (FGR)					√*							60%		2,470	2,560	2,560
Ammonia - Natural Gas - Fired Reformers - Small Sources	Selective Non-Catalytic Reduction (SNCR)					√*			X				50%		2,900	3,870	3,870
Ammonia - Natural Gas - Fired Reformers - Small Sources	Selective Catalytic Reduction (SCR)					√*			X				80%		2,230	2,230	2,860
Ammonia - Natural Gas - Fired Reformers - Small Sources	Oxygen Trim + Water Injection					√*							65%			680	
Ammonia Products; Feedstock Desulfurization - Small Sources	Low NOx Burner + Flue Gas Recirculation					√*							60%		2,470	2,560	2,560

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Architectural Coatings	OTC AIM Coating Rule						√*						55%			6,628	
Architectural Coatings	AIM Coating Federal Rule						√*						20%			228	
Architectural Coatings	South Coast Phase III						√*						73%			10,059	
Architectural Coatings	South Coast Phase II						√*						47%			4,017	
Architectural Coatings	South Coast Phase I						√*						34%		3,300	1,443	4,600
AREA	OTC Mobile Equipment Repair and Refinishing Rule						√*						61%			2,534	
AREA	OTC Consumer Products Rule						√*						39.2%			1,032	
AREA	OTC Mobile Equipment Repair and Refinishing Rule						√*						61%			2,534	
AREA	OTC Mobile Equipment Repair and Refinishing Rule						√*						61%			2,534	
AREA	OTC Consumer Products Rule						√*						39.2%			1,032	
AREA	OTC Mobile Equipment Repair and Refinishing Rule						√*						61%			2,534	

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
AREA	OTC Solvent Cleaning Rule						√*						66%			1,400	
Asphalt Manufacture	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	
Asphalt Manufacture	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	
Asphalt Manufacture	Paper/Nonwoven Filters - Cartridge Collector Type	√	√*	√	√								99%		85	147	256
Asphalt Manufacture	Fabric Filter (Pulse Jet Type)	√	√*	√	√								99%		42	117	266
Asphalt Manufacture	Fabric Filter (Mech. Shaker Type)	√	√*	√	√								99%		37	126	303
Asphalt Manufacture	Fabric Filter (Reverse-Air Cleaned Type)	√	√*	√	√								99%		53	148	337
Asphaltic Conc; Rotary Dryer; Conv Plant - Small Sources	Low NOx Burner					√*							50%			2,200	
Automobile Refinishing	Federal Rule						√*						37%			118	
Automobile Refinishing	CARB BARCT Limits						√*						47%			750	
Automobile Refinishing	California FIP Rule (VOC content & TE)						√*						89%			7,200	

Source Category	Control Measure Name	Pollutant(s) Affected											Control Efficiency			Average Annual Cost Effectiveness		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant											(% from baseline)			(\$/ton primary pollutant)		
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg	Low	Typical	High	Low	Typical	High	
Bakery Products	Incineration >100,000 lbs bread						√*						39.9%			1,470		
Beef Cattle Feedlots	Watering	√	√*	√	√								50%			307		
Bituminous/Subbituminous Coal	Flue Gas Desulfurization							√*					90%			N/A		
Bituminous/Subbituminous Coal	Flue Gas Desulfurization							√*					90%			N/A		
Bituminous/Subbituminous Coal (Industrial Boilers)	In-duct Dry Sorbent Injection							√*					40%		1,111	1,526	2,107	
Bituminous/Subbituminous Coal (Industrial Boilers)	Wet Flue Gas Desulfurization							√*					90%		1,027	1,536	1,980	
Bituminous/Subbituminous Coal (Industrial Boilers)	Spray Dryer Absorber							√*					90%		804	1,341	1,973	
By-Product Coke Manufacturing	Vacuum Carbonate Plus Sulfur Recovery Plant							√*					82%			N/A		
By-Product Coke Manufacturing; Oven Underfiring	Selective Non-Catalytic Reduction (SNCR)					√*			X				60%			1,640		
Cattle Feedlots	Chemical Additives to Waste								√*				50%			228		
Cement Kilns	Biosolid Injection					√*							23%			310		

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Cement Manufacturing - Dry	Selective Catalytic Reduction (SCR)					√*			X				80%			3,370	
Cement Manufacturing - Dry	Selective Non-Catalytic Reduction (SNCR) Ammonia Based					√*			X				50%			850	
Cement Manufacturing - Dry	Selective Non-Catalytic Reduction (SNCR) Urea Based					√*			X				50%			770	
Cement Manufacturing - Dry	Mid-Kiln Firing					√*							25%		-460	55	730
Cement Manufacturing - Dry	Low NOx Burner					√*							25%		300	440	620
Cement Manufacturing - Wet	Low NOx Burner					√*							25%		300	440	620
Cement Manufacturing - Wet	Mid-Kiln Firing					√*							25%		-460	55	730
Cement Manufacturing - Wet - Large Sources	Selective Catalytic Reduction (SCR)					√*			X				80%			2,880	
Cement Manufacturing - Wet - Small Sources	Selective Catalytic Reduction (SCR)					√*			X				80%			2,880	
Ceramic Clay Manufacturing; Drying - Small Sources	Low NOx Burner					√*							50%			2,200	
Chemical Manufacture	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Chemical Manufacture	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	
Chemical Manufacture	Wet ESP - Wire Plate Type	√	√*	√	√								99%		55	220	550
Coal Cleaning-Thrml Dryer; Fluidized Bed - Small Sources	Low NOx Burner					√*							50%			1,460	
Coal-fired Plants with Production Capacities>100MW	Combustion Optimization					√*							20%			-25	
Combustion Turbines - Jet Fuel - Small Sources	Water Injection					√*							68%			1,290	
Combustion Turbines - Jet Fuel - Small Sources	Selective Catalytic Reduction (SCR) + Water Injection					√*							90%			2,300	
Combustion Turbines - Natural Gas - Large Sources	Dry Low NOx Combustors					√*							50%		100	100	140
Combustion Turbines - Natural Gas - Small Sources	Selective Catalytic Reduction (SCR) + Water Injection					√*							95%			2,730	
Combustion Turbines - Natural Gas - Small Sources	Water Injection					√*							76%			1,510	
Combustion Turbines - Natural Gas - Small Sources	Steam Injection					√*							80%			1,040	
Combustion Turbines - Natural Gas - Small Sources	Dry Low NOx Combustors					√*							84%		490	490	540

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Combustion Turbines - Natural Gas - Small Sources	Selective Catalytic Reduction (SCR) + Low NOx Burner (LNB)					√*			X				94%		2,570	2,570	19,120
Combustion Turbines - Natural Gas - Small Sources	Selective Catalytic Reduction (SCR) + Steam Injection					√*			X				95%		2,010	2,010	8,960
Combustion Turbines - Oil - Small Sources	Selective Catalytic Reduction (SCR) + Water Injection					√*							90%			2,300	
Combustion Turbines - Oil - Small Sources	Water Injection					√*							68%			1,290	
Commercial Adhesives	CARB Long-Term Limits						√*						85%			2,880	
Commercial Adhesives	CARB Mid-Term Limits						√*						55%			2,192	
Commercial Adhesives	Federal Consumer Solvents Rule						√*						25%			232	
Commercial Institutional Boilers - Coal	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	
Commercial Institutional Boilers - Coal	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	
Commercial Institutional Boilers - Coal	Fabric Filter (Reverse-Air Cleaned Type)	√	√*	√	√								99%		53	148	337
Commercial Institutional Boilers - Coal	Dry ESP-Wire Plate Type	√	√*	√	√								98%		40	110	250

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Commercial Institutional Boilers - Coal	Fabric Filter (Pulse Jet Type)	√	√*	√	√								99%		42	117	266
Commercial Institutional Boilers - Liquid Waste	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	
Commercial Institutional Boilers - Liquid Waste	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	
Commercial Institutional Boilers - LPG	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	
Commercial Institutional Boilers - LPG	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	
Commercial Institutional Boilers - Natural Gas	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	
Commercial Institutional Boilers - Natural Gas	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	
Commercial Institutional Boilers - Oil	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	
Commercial Institutional Boilers - Oil	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	
Commercial Institutional Boilers - Oil	Dry ESP-Wire Plate Type	√	√*	√	√								98%		40	110	250
Commercial Institutional Boilers - Process Gas	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Commercial Institutional Boilers - Process Gas	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	
Commercial Institutional Boilers - Solid Waste	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	
Commercial Institutional Boilers - Solid Waste	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	
Commercial Institutional Boilers - Wood	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	
Commercial Institutional Boilers - Wood	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	
Commercial Institutional Boilers - Wood/Bark	Dry ESP-Wire Plate Type	√	√*	√	√								98%		40	110	250
Commercial Institutional Boilers - Wood/Bark	Fabric Filter (Reverse-Air Cleaned Type)	√	√*	√	√								99%		53	148	337
Commercial Institutional Boilers - Wood/Bark	Fabric Filter (Pulse Jet Type)	√	√*	√	√								99%		42	117	266
Commercial/Institutional - Natural Gas	Water Heater Replacement					√*							7%			N/A	
Commercial/Institutional - Natural Gas	Water Heaters + LNB Space Heaters					√*							7%			1,230	
Commercial/Institutional Incinerators	Selective Non-Catalytic Reduction (SNCR)					√*			X				45%			1,130	

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Construction Activities	Dust Control Plan	√	√*	√	√								62.5%			3,600	
Consumer Solvents	Federal Consumer Solvents Rule						√*						25%			232	
Consumer Solvents	CARB Mid-Term Limits						√*						55%			2,192	
Consumer Solvents	CARB Long-Term Limits						√*						85%			2,880	
Conv Coating of Prod; Acid Cleaning Bath - Small Sources	Low NOx Burner					√*							50%			2,200	
Conveyorized Charbroilers	Catalytic Oxidizer	√*	√*				√					80%	83%	90%		2,966	
Cutback Asphalt	Switch to Emulsified Asphalts						√*						100%			15	
Diesel Locomotives	Selective Catalytic Reduction (SCR)					√*							72%			1,400	
Distillate Oil (Industrial Boiler)	Wet Flue Gas Desulfurization							√*					90%		2,295	3,489	4,524
Electric Generation - Coke	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	
Electric Generation - Coke	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Electric Generation - Bagasse	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	
Electric Generation - Bagasse	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	
Electric Generation - Coal	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	
Electric Generation - Coal	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	
Electric Generation - Liquid Waste	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	
Electric Generation - Liquid Waste	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	
Electric Generation - LPG	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	
Electric Generation - LPG	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	
Electric Generation - Natural Gas	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	
Electric Generation - Natural Gas	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	
Electric Generation - Oil	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Electric Generation - Oil	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	
Electric Generation - Solid Waste	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	
Electric Generation - Solid Waste	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	
Electric Generation - Wood	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	
Electric Generation - Wood	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	
Electrical/Electronic Coating	MACT Standard						√*						36%			5,000	
Electrical/Electronic Coating	SCAQMD Rule						√*						70%			5,976	
Fabric Printing, Coating and Dyeing	Permanent Total Enclosure (PTE)						√*									N/A	
Fabricated Metal Products - Abrasive Blasting	Paper/Nonwoven Filters - Cartridge Collector Type	√	√*	√	√								99%		85	142	256
Fabricated Metal Products - Welding	Paper/Nonwoven Filters - Cartridge Collector Type	√	√*	√	√								99%		85	142	256
Ferrous Metals Processing - Coke	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Ferrous Metals Processing - Coke	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	
Ferrous Metals Processing - Coke	Fabric Filter (Mech. Shaker Type)	√	√*	√	√								99%		37	126	303
Ferrous Metals Processing - Coke	Fabric Filter (Reverse-Air Cleaned Type)	√	√*	√	√								99%		53	148	337
Ferrous Metals Processing - Coke	Venturi Scrubber	√	√*	√	√								93%		75	751	2,100
Ferrous Metals Processing - Ferroalloy Production	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	
Ferrous Metals Processing - Ferroalloy Production	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	
Ferrous Metals Processing - Ferroalloy Production	Fabric Filter (Mech. Shaker Type)	√	√*	√	√								99%		37	126	303
Ferrous Metals Processing - Ferroalloy Production	Dry ESP-Wire Plate Type	√	√*	√	√								98%		40	110	250
Ferrous Metals Processing - Ferroalloy Production	Fabric Filter (Reverse-Air Cleaned Type)	√	√*	√	√								99%		53	148	337
Ferrous Metals Processing - Gray Iron Foundries	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	
Ferrous Metals Processing - Gray Iron Foundries	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Ferrous Metals Processing - Gray Iron Foundries	Fabric Filter (Mech. Shaker Type)	√	√*	√	√								99%		37	126	303
Ferrous Metals Processing - Gray Iron Foundries	Dry ESP-Wire Plate Type	√	√*	√	√								98%		40	110	250
Ferrous Metals Processing - Gray Iron Foundries	Fabric Filter (Reverse-Air Cleaned Type)	√	√*	√	√								99%		53	148	337
Ferrous Metals Processing - Gray Iron Foundries	Impingement-Plate Scrubber	√	√*	√	√								64%		46	431	1,200
Ferrous Metals Processing - Gray Iron Foundries	Venturi Scrubber	√	√*	√	√								94%		76	751	2,100
Ferrous Metals Processing - Iron & Steel Production	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	
Ferrous Metals Processing - Iron & Steel Production	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	
Ferrous Metals Processing - Iron and Steel Production	Fabric Filter (Reverse-Air Cleaned Type)	√	√*	√	√								99%		53	148	337
Ferrous Metals Processing - Iron and Steel Production	Wet ESP - Wire Plate Type	√	√*	√	√								99%		55	220	550
Ferrous Metals Processing - Iron and Steel Production	Fabric Filter (Pulse Jet Type)	√	√*	√	√								99%		42	117	266
Ferrous Metals Processing - Iron and Steel Production	Dry ESP-Wire Plate Type	√	√*	√	√								98%		40	110	250

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Ferrous Metals Processing - Iron and Steel Production	Venturi Scrubber	√	√*	√	√								73%		76	751	2,100
Ferrous Metals Processing - Iron and Steel Production	Fabric Filter (Mech. Shaker Type)	√	√*	√	√								99%		37	126	303
Ferrous Metals Processing - Other	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	
Ferrous Metals Processing - Other	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	
Ferrous Metals Processing - Steel Foundries	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	
Ferrous Metals Processing - Steel Foundries	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	
Ferrous Metals Processing - Steel Foundries	Venturi Scrubber	√	√*	√	√								73%		76	751	2,100
Ferrous Metals Processing - Steel Foundries	Fabric Filter (Pulse Jet Type)	√	√*	√	√								99%		42	117	266
Ferrous Metals Processing - Steel Foundries	Wet ESP - Wire Plate Type	√	√*	√	√								99%		55	220	550
Ferrous Metals Processing - Steel Foundries	Fabric Filter (Reverse-Air Cleaned Type)	√	√*	√	√								99%		53	148	337
Ferrous Metals Processing - Steel Foundries	Dry ESP-Wire Plate Type	√	√*	√	√								98%		40	110	250

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Ferrous Metals Processing - Steel Foundries	Fabric Filter (Mech. Shaker Type)	√	√*	√	√								99%		37	126	303
Fiberglass Manufacture; Textile-Type; Recuperative Furnaces	Low NOx Burner					√*							40%			1,690	
Flexographic Printing	Permanent Total Enclosure (PTE)						√*						95			9,947	
Fluid Catalytic Cracking Units - Small Sources	Low NOx Burner + Flue Gas Recirculation					√*							55%		1,430	3,190	3,190
Fuel Fired Equipment - Process Heaters	Low Nox Burner + Flue Gas Recirculation					√*							50%			570	
Fuel Fired Equipment; Furnaces; Natural Gas	Low NOx Burner					√*							50%			570	
Glass Manufacturing - Containers	Selective Non-Catalytic Reduction (SNCR)					√*			X				40%			1,770	
Glass Manufacturing - Containers	Selective Catalytic Reduction (SCR)					√*			X				75%			2,200	
Glass Manufacturing - Containers	Low NOx Burner					√*							40%			1,690	
Glass Manufacturing - Containers	Cullet Preheat					√*							25%			940	
Glass Manufacturing - Containers	Electric Boost					√*							10%			7,150	

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Glass Manufacturing - Containers	OXY-Firing					√*							85%			4,590	
Glass Manufacturing - Flat	OXY-Firing					√*							85%			1,900	
Glass Manufacturing - Flat	Electric Boost					√*							10%			2,320	
Glass Manufacturing - Flat	Low NOx Burner					√*							40%			700	
Glass Manufacturing - Flat - Large Sources	Selective Non-Catalytic Reduction (SNCR)					√*			X				40%			740	
Glass Manufacturing - Flat - Large Sources	Selective Catalytic Reduction (SCR)					√*			X				75%			710	
Glass Manufacturing - Flat - Small Sources	Selective Non-Catalytic Reduction (SNCR)					√*			X				40%			740	
Glass Manufacturing - Flat - Small Sources	Selective Catalytic Reduction (SCR)					√*			X				75%			710	
Glass Manufacturing - Pressed	Low NOx Burner					√*							40%			1,500	
Glass Manufacturing - Pressed	Selective Non-Catalytic Reduction (SNCR)					√*			X				40%			1,640	
Glass Manufacturing - Pressed	Selective Catalytic Reduction (SCR)					√*			X				75%			2,530	

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Glass Manufacturing - Pressed	OXY-Firing					√*							85%			3,900	
Glass Manufacturing - Pressed	Cullet Preheat					√*							25%			810	
Glass Manufacturing - Pressed	Electric Boost					√*							10%			8,760	
Grain Milling	Fabric Filter (Pulse Jet Type)	√	√*	√	√								99%		42	117	266
Grain Milling	Fabric Filter (Reverse-Air Cleaned Type)	√	√*	√	√								99%		53	148	337
Grain Milling	Paper/Nonwoven Filters - Cartridge Collector Type	√	√*	√	√								99%		85	142	256
Graphic Arts	Use of Low or No VOC Materials						√*						65%		3,500	4,150	4,800
Highway Vehicles - Gasoline Engine	Federal Reformulated Gasoline (RFG)					X	√*			√		0%	7.65%	15.3%	2,498	25,093	
Highway Vehicles - Gasoline Engine	Low Reid Vapor Pressure (RVP) Limit in Ozone Season					√	√*			√		0.1%	5.5%	11.1%	125	1,548	25,671
Highway Vehicles - Gasoline Engine	RFG and High Enhanced I/M Program					√	√*			√		-9.1%	11.4%	31.9%	484	16,164	
Highway Vehicles - Heavy Duty and Diesel-Fueled Vehicles	Heavy Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Controls	√	√			√*	√	√		√			61%			10,561	

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Highway Vehicles - Heavy Duty and Diesel-Fueled Vehicles	Heavy Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Controls	√	√			√*	√	√		√			76%			10,561	
Highway Vehicles - Heavy Duty and Diesel-Fueled Vehicles	Heavy Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Controls	√	√			√*	√	√		√			19%			9,301	
Highway Vehicles - Heavy Duty and Diesel-Fueled Vehicles	Heavy Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Controls	√	√			√*	√	√		√			44%			10,561	
Highway Vehicles - Heavy Duty Diesel Engines	Voluntary Diesel Retrofit Program: Selective Catalytic Reduction	√	√			√*	√	√		√			19.26%			50,442	
Highway Vehicles - Heavy Duty Diesel Engines	Voluntary Diesel Retrofit Program: Biodiesel Fuel	√	√*				√			√			7%			209,913	
Highway Vehicles - Heavy Duty Diesel Engines	Voluntary Diesel Retrofit Program: Diesel Particulate Filter	√	√*				√	√		√			61.99%			727,689	
Highway Vehicles - Heavy Duty Diesel Engines	Voluntary Diesel Retrofit Program: Diesel Oxidation Catalyst	√	√*				√	√		√			24.01%			167,640	
Highway Vehicles - Light Duty and Gasoline-Fueled Vehicles	Tier 2 Motor Vehicle Emissions and Gasoline Sulfur Controls	√	√			√*	√	√		√		28%	34%	40%		6,297	
Highway Vehicles - Light Duty and Gasoline-Fueled Vehicles	Tier 2 Motor Vehicle Emissions and Gasoline Sulfur Controls	√	√			√*	√	√		√		43%	54.5%	66%		6,297	
Highway Vehicles - Light Duty and Gasoline-Fueled Vehicles	Tier 2 Motor Vehicle Emissions and Gasoline Sulfur Controls	√	√			√*	√	√		√		74%	83%	92%		6,297	
Highway Vehicles - Light Duty and Gasoline-Fueled Vehicles	Tier 2 Motor Vehicle Emissions and Gasoline Sulfur Controls	√	√			√*	√	√		√		52%	64.5%	77%		6,297	

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Highway Vehicles - Light Duty Gasoline Engines	Basic Inspection and Maintenance Program	√	√			√	√*	√	√	√						N/A	
Highway Vehicles - Light Duty Gasoline Engines	High Enhanced Inspection and Maintenance (I/M) Program					√*	√			√		0.4%	6.5%	13.4%	3,900	7,949	218,369
Hog Operations	Chemical Additives to Waste								√*				50%			73	
IC Engines - Gas	L-E (Low Speed)					√*							87%			176	
IC Engines - Gas - Small Sources	Selective Catalytic Reduction (SCR)					√*							90%			2,769	
IC Engines - Gas, Diesel, LPG - Small Sources	Selective Catalytic Reduction (SCR)					√*							80%			2,340	
IC Engines - Gas, Diesel, LPG - Small Sources	Ignition Retard					√*							25%			770	
ICI Boilers - Coal/Cyclone - Large Sources	Coal Reburn					√*							50%			300	
ICI Boilers - Coal/Cyclone - Small Sources	Natural Gas Reburn (NGR)					√*							55%			1,570	
ICI Boilers - Coal/Cyclone - Small Sources	Selective Catalytic Reduction (SCR)					√*							80%			820	
ICI Boilers - Coal/Cyclone - Small Sources	Coal Reburn					√*							50%			1,570	

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
ICI Boilers - Coal/Cyclone - Small Sources	Selective Non-Catalytic Reduction (SNCR)					√*			X				35%			840	
ICI Boilers - Coal/FBC - Large Sources	Selective Non-Catalytic Reduction (SNCR) Urea Based					√*			X				40%			670	
ICI Boilers - Coal/FBC - Small Sources	Selective Non-Catalytic Reduction (SNCR) Urea Based					√*			X				75%			900	
ICI Boilers - Coal/Stoker - Small Sources	Selective Non-Catalytic Reduction (SNCR)					√*			X				40%		873	1,015	1,015
ICI Boilers - Coal/Stoker - Small Sources	Selective Non-Catalytic Reduction (SNCR)					√*			X				40%			817	
ICI Boilers - Coal/Wall - Large Sources	Selective Non-Catalytic Reduction (SNCR)					√*			X				40%			840	
ICI Boilers - Coal/Wall - Large Sources	Selective Catalytic Reduction (SCR)					√*			X				70%			1,070	
ICI Boilers - Coal/Wall - Large Sources	Low NOx Burner					√*							50%			1,090	
ICI Boilers - Coal/Wall - Small Sources	Selective Non-Catalytic Reduction (SNCR)					√*			X				40%		400	1,040	1,040
ICI Boilers - Coal/Wall - Small Sources	Selective Catalytic Reduction (SCR)					√*							70%			1,260	
ICI Boilers - Coal/Wall - Small Sources	Low NOx Burner					√*							50%			1,460	

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
ICI Boilers - Coke - Small Sources	Selective Catalytic Reduction (SCR)					√*			X				70%			1,260	
ICI Boilers - Coke - Small Sources	Low NOx Burner					√*							50%			1,460	
ICI Boilers - Coke - Small Sources	Selective Non-Catalytic Reduction (SNCR)					√*			X				40%		400	1,040	1,040
ICI Boilers - Distillate Oil - Large Sources	Selective Non-Catalytic Reduction (SNCR)					√*			X				50%			1,890	
ICI Boilers - Distillate Oil - Small Sources	Low NOx Burner					√*							50%			1,180	
ICI Boilers - Distillate Oil - Small Sources	Low NOx Burner + Flue Gas Recirculation					√*							60%		1,090	2,490	2,490
ICI Boilers - Distillate Oil - Small Sources	Selective Catalytic Reduction (SCR)					√*			X				80%		2,780	2,780	3,570
ICI Boilers - Distillate Oil - Small Sources	Selective Non-Catalytic Reduction (SNCR)					√*			X				50%		3,470	4,640	4,640
ICI Boilers - Liquid Waste	Selective Catalytic Reduction (SCR)					√*			X				80%		1,480	1,480	1,910
ICI Boilers - Liquid Waste - Small Sources	Low NOx Burner + Flue Gas Recirculation					√*							60%		1,120	1,120	1,080
ICI Boilers - Liquid Waste - Small Sources	Low NOx Burner					√*							50%			400	

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
ICI Boilers - Liquid Waste - Small Sources	Selective Non-Catalytic Reduction (SNCR)					√*			X				50%		1,940	2,580	2,580
ICI Boilers - LPG - Small Sources	Selective Non-Catalytic Reduction (SNCR)					√*			X				50%		3,470	4,640	4,640
ICI Boilers - LPG - Small Sources	Selective Catalytic Reduction (SCR)					√*			X				80%		2,780	2,780	3,570
ICI Boilers - LPG - Small Sources	Low NOx Burner + Flue Gas Recirculation					√*							60%		1,090	2,490	2,490
ICI Boilers - LPG - Small Sources	Low NOx Burner					√*							50%			1,180	
ICI Boilers - MSW/Stoker - Small Sources	Selective Non-Catalytic Reduction (SNCR) Urea Based					√*			X				55%			1,690	
ICI Boilers - Natural Gas - Large Sources	Selective Non-Catalytic Reduction (SNCR)					√*			X				50%			1,570	
ICI Boilers - Natural Gas - Small Sources	Selective Catalytic Reduction (SCR)					√*			X				80%		2,230	2,230	2,860
ICI Boilers - Natural Gas - Small Sources	Selective Non-Catalytic Reduction (SNCR)					√*			X				50%		2,900	3,870	3,870
ICI Boilers - Natural Gas - Small Sources	Low NOx Burner + Flue Gas Recirculation					√*							60%		2,470	2,560	2,560
ICI Boilers - Natural Gas - Small Sources	Oxygen Trim + Water Injection					√*							65%			680	

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
ICI Boilers - Natural Gas - Small Sources	Low NOx Burner					√*							50%			820	
ICI Boilers - Process Gas - Small Sources	Oxygen Trim + Water Injection					√*							65%			680	
ICI Boilers - Process Gas - Small Sources	Low NOx Burner + Flue Gas Recirculation					√*							60%		2,470	2,560	2,560
ICI Boilers - Process Gas - Small Sources	Low NOx Burner					√*							50%			820	
ICI Boilers - Process Gas - Small Sources	Selective Catalytic Reduction (SCR)					√*			X				80%		2,230	2,230	2,860
ICI Boilers - Residual Oil - Large Sources	Selective Non-Catalytic Reduction (SNCR)					√*			X				50%			1,050	
ICI Boilers - Residual Oil - Small Sources	Selective Catalytic Reduction (SCR)					√*			X				80%		1,480	1,480	1,910
ICI Boilers - Residual Oil - Small Sources	Low NOx Burner + Flue Gas Recirculation					√*							60%		1,120	1,120	1,080
ICI Boilers - Residual Oil - Small Sources	Low NOx Burner					√*							50%			400	
ICI Boilers - Residual Oil - Small Sources	Selective Non-Catalytic Reduction (SNCR)					√*			X				50%		1,940	2,580	2,580
ICI Boilers - Wood/Bark/Stoker - Large Sources	Selective Non-Catalytic Reduction (SNCR) Urea Based					√*			X				55%			1,190	

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
ICI Boilers - Wood/Bark/Stoker - Small Sources	Selective Non-Catalytic Reduction (SNCR) Urea Based					√*			X				55%			1,440	
Industrial Boilers - Coal	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	
Industrial Boilers - Coal	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	
Industrial Boilers - Coal	Venturi Scrubber	√	√*	√	√								82%		76	751	2,100
Industrial Boilers - Coal	Dry ESP-Wire Plate Type	√	√*	√	√								98%		40	110	250
Industrial Boilers - Coal	Fabric Filter (Pulse Jet Type)	√	√*	√	√								99%		42	117	266
Industrial Boilers - Coal	Fabric Filter (Reverse-Air Cleaned Type)	√	√*	√	√								99%		53	148	337
Industrial Boilers - Coke	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	
Industrial Boilers - Coke	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	
Industrial Boilers - Liquid Waste	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	
Industrial Boilers - Liquid Waste	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Industrial Boilers - Liquid Waste	Dry ESP-Wire Plate Type	√	√*	√	√								98%		40	110	250
Industrial Boilers - LPG	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	
Industrial Boilers - LPG	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	
Industrial Boilers - Natural Gas	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	
Industrial Boilers - Natural Gas	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	
Industrial Boilers - Oil	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	
Industrial Boilers - Oil	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	
Industrial Boilers - Oil	Venturi Scrubber	√	√*	√	√								92%		76	751	2,100
Industrial Boilers - Oil	Dry ESP-Wire Plate Type	√	√*	√	√								98%		40	110	250
Industrial Boilers - Process Gas	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	
Industrial Boilers - Process Gas	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Industrial Boilers - Solid Waste	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	
Industrial Boilers - Solid Waste	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	
Industrial Boilers - Wood	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	
Industrial Boilers - Wood	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	
Industrial Boilers - Wood	Venturi Scrubber	√	√*	√	√								93%		76	751	2,100
Industrial Boilers - Wood	Fabric Filter (Reverse-Air Cleaned Type)	√	√*	√	√								99%		53	148	337
Industrial Boilers - Wood	Dry ESP-Wire Plate Type	√	√*	√	√								98%		40	110	250
Industrial Boilers - Wood	Fabric Filter (Pulse Jet Type)	√	√*	√	√								99%		42	117	266
Industrial Coal Combustion	RACT to 50 tpy (LNB)					√*							21%			1,350	
Industrial Coal Combustion	RACT to 25 tpy (LNB)					√*							21%			1,350	
Industrial Incinerators	Selective Non-Catalytic Reduction (SNCR)					√*			X				45%			1,130	

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Industrial Maintenance Coating	AIM Coating Federal Rule						√*						20%			228	
Industrial Maintenance Coating	South Coast Phase III						√*						73%			10,059	
Industrial Maintenance Coating	South Coast Phase I						√*						34%		3,300	1,443	4,600
Industrial Maintenance Coating	South Coast Phase II						√*						47%			4,017	
Industrial Natural Gas Combustion	RACT to 25 tpy (LNB)					√*							31%			770	
Industrial Natural Gas Combustion	RACT to 50 tpy (LNB)					√*							31%			770	
Industrial Oil Combustion	RACT to 50 tpy (LNB)					√*							36%			1,180	
Industrial Oil Combustion	RACT to 25 tpy (LNB)					√*							36%			1,180	
Inorganic Chemical Manufacture	Flue Gas Desulfurization							√*					90%			N/A	
In-Proc; Process Gas; Coke Oven/Blast Ovens	Low NOx Burner + Flue Gas Recirculation					√*							55%		1,430	3,190	3,190
In-process Fuel Use - Bituminous Coal	Flue Gas Desulfurization							√*					90%			N/A	

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
In-Process Fuel Use - Bituminous Coal - Small Sources	Selective Non-Catalytic Reduction (SNCR)					√*			X				40%			1,260	
In-Process Fuel Use; Natural Gas - Small Sources	Low NOx Burner					√*							50%			2,200	
In-Process Fuel Use; Residual Oil - Small Sources	Low NOx Burner					√*							37%			2,520	
In-Process; Bituminous Coal; Cement Kilns	Selective Non-Catalytic Reduction (SNCR) Urea Based					√*			X				50%			770	
In-Process; Bituminous Coal; Lime Kilns	Selective Non-Catalytic Reduction (SNCR) Urea Based					√*			X				50%			770	
In-Process; Process Gas; Coke Oven Gas	Low NOx Burner					√*							50%			2,200	
Internal Combustion Engines - Gas	L-E (Medium Speed)					√*							87%			380	
Internal Combustion Engines - Gas - Large Sources	Air/Fuel + Ignition Retard					√*							30%		150	460	460
Internal Combustion Engines - Gas - Large Sources	Air/Fuel Ratio Adjustment					√*							20%			380	
Internal Combustion Engines - Gas - Large Sources	Ignition Retard					√*							20%			550	
Internal Combustion Engines - Gas - Small Sources	Air/Fuel + Ignition Retard					√*							30%		270	1,440	1,440

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Internal Combustion Engines - Gas - Small Sources	Air/Fuel Ratio Adjustment					√*							20%			1,570	
Internal Combustion Engines - Gas - Small Sources	Ignition Retard					√*							20%			1,020	
Internal Combustion Engines - Oil - Small Sources	Ignition Retard					√*							25%			770	
Internal Combustion Engines - Oil - Small Sources	Selective Catalytic Reduction (SCR)					√*			X				80%			2,340	
Iron & Steel Mills - Annealing	Low NOx Burner (LNB) + SCR					√*			X				80%		1,320	1,720	1,720
Iron & Steel Mills - Annealing	Low NOx Burner + Flue Gas Recirculation					√*							60%		250	750	750
Iron & Steel Mills - Annealing	Low NOx Burner					√*							50%			570	
Iron & Steel Mills - Annealing	Selective Non-Catalytic Reduction (SNCR)					√*			X				60%			1,640	
Iron & Steel Mills - Annealing - Small Sources	Selective Catalytic Reduction (SCR)					√*			X				85%			3,830	
Iron & Steel Mills - Annealing - Small Sources	Low NOx Burner (LNB) + Selective Catalytic Reduction (SCR)					√*			X				90%		3,720	4,080	4,080
Iron & Steel Mills - Galvanizing	Low NOx Burner + Flue Gas Recirculation					√*							60%		190	580	580

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		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Iron & Steel Mills - Galvanizing	Low NOx Burner					√*							50%			490	
Iron & Steel Mills - Reheating	Low Excess Air (LEA)					√*							13%			1,320	
Iron & Steel Mills - Reheating	Low NOx Burner					√*							66%			300	
Iron & Steel Mills - Reheating	Low NOx Burner + Flue Gas Recirculation					√*							77%		150	380	380
Iron Production; Blast Furnaces; Blast Heating Stoves	Low NOx Burner + Flue Gas Recirculation					√*							77%			380	
Lignite (Industrial Boiler)	In-duct Dry Sorbent Injection							√*					40%		1,111	1,526	2,107
Lignite (Industrial Boiler)	Spray Dryer Absorber							√*					90%		804	1,341	1,973
Lignite (Industrial Boiler)	Wet Flue Gas Desulfurization							√*					90%		1,027	1,536	1,980
Lignite (Industrial Boilers)	Flue Gas Desulfurization							√*					90%			N/A	
Lime Kilns	Low NOx Burner					√*							30%			560	
Lime Kilns	Mid-Kiln Firing					√*							30%			460	

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		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Lime Kilns	Selective Non-Catalytic Reduction (SNCR) Urea Based					√*			X				50%			770	
Lime Kilns	Selective Non-Catalytic Reduction (SNCR) Ammonia Based					√*			X				50%			850	
Lime Kilns	Selective Catalytic Reduction (SCR)					√*			X				80%			3,370	
Machinery, Equipment, and Railroad Coating	SCAQMD Limits						√*						55.2%			2,027	
Marine Surface Coating (Shipbuilding)	Add-On Controls						√*						90%			8,937	
Marine Surface Coating (Shipbuilding)	MACT Standard						√*						24%			2,090	
Medical Waste Incinerators	Selective Non-Catalytic Reduction (SNCR)					√*			X				45%			4,510	
Metal Can Surface Coating Operations	Permanent Total Enclosure (PTE)						√*						95			8,469	
Metal Coil & Can Coating	Incineration						√*						90%			8,937	
Metal Coil & Can Coating	BAAQMD Rule 11 Amended						√*						42%			2,007	
Metal Coil & Can Coating	MACT Standard						√*						36%			1,000	

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		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Metal Furniture Surface Coating Operations	Permanent Total Enclosure (PTE)						√*						95			19,321	
Metal Furniture, Appliances, Parts	SCAQMD Limits						√*						55.2%			2,027	
Metal Furniture, Appliances, Parts	MACT Standard						√*						36%			1,000	
Mineral Products - Cement Manufacture	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	
Mineral Products - Cement Manufacture	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	
Mineral Products - Cement Manufacture	Fabric Filter (Pulse Jet Type)	√	√*	√	√								99%		42	117	266
Mineral Products - Cement Manufacture	Fabric Filter (Mech. Shaker Type)	√	√*	√	√								99%		37	126	303
Mineral Products - Cement Manufacture	Dry ESP-Wire Plate Type	√	√*	√	√								98%		40	110	250
Mineral Products - Cement Manufacture	Paper/Nonwoven Filters - Cartridge Collector Type	√	√*	√	√								99%		85	142	256
Mineral Products - Cement Manufacture	Fabric Filter (Reverse-Air Cleaned Type)	√	√*	√	√								99%		53	148	337
Mineral Products - Coal Cleaning	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Mineral Products - Coal Cleaning	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	
Mineral Products - Coal Cleaning	Venturi Scrubber	√	√*	√	√								99%		76	751	2,100
Mineral Products - Coal Cleaning	Fabric Filter (Reverse-Air Cleaned Type)	√	√*	√	√								99%		53	148	337
Mineral Products - Coal Cleaning	Fabric Filter (Pulse Jet Type)	√	√*	√	√								99%		42	117	266
Mineral Products - Coal Cleaning	Fabric Filter (Mech. Shaker Type)	√	√*	√	√								99%		37	126	303
Mineral Products - Coal Cleaning	Paper/Nonwoven Filters - Cartridge Collector Type	√	√*	√	√								99%		85	142	256
Mineral Products - Other	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	
Mineral Products - Other	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	
Mineral Products - Other	Fabric Filter (Pulse Jet Type)	√	√*	√	√								99%		42	117	266
Mineral Products - Other	Fabric Filter (Reverse-Air Cleaned Type)	√	√*	√	√								99%		53	148	337
Mineral Products - Other	Dry ESP-Wire Plate Type	√	√*	√	√								98%		40	110	250

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Mineral Products - Other	Wet ESP - Wire Plate Type	√	√*	√	√								99%		55	220	550
Mineral Products - Other	Paper/Nonwoven Filters - Cartridge Collector Type	√	√*	√	√								99%		85	145	256
Mineral Products - Other	Fabric Filter (Mech. Shaker Type)	√	√*	√	√								99%		37	126	303
Mineral Products - Stone Quarrying & Processing	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	
Mineral Products - Stone Quarrying & Processing	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	
Mineral Products - Stone Quarrying and Processing	Fabric Filter (Mech. Shaker Type)	√	√*	√	√								99%		37	126	303
Mineral Products - Stone Quarrying and Processing	Fabric Filter (Pulse Jet Type)	√	√*	√	√								99%		42	117	266
Mineral Products - Stone Quarrying and Processing	Wet ESP - Wire Plate Type	√	√*	√	√								99%		55	220	550
Mineral Products - Stone Quarrying and Processing	Dry ESP-Wire Plate Type	√	√*	√	√								98%		40	110	250
Mineral Products - Stone Quarrying and Processing	Paper/Nonwoven Filters - Cartridge Collector Type	√	√*	√	√								99%		85	142	256
Mineral Products - Stone Quarrying and Processing	Fabric Filter (Reverse-Air Cleaned Type)	√	√*	√	√								99%		53	148	337

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Mineral Products - Stone Quarrying and Processing	Venturi Scrubber	√	√*	√	√								95%		76	751	2,100
Mineral Products Industry	Flue Gas Desulfurization							√*					90%			N/A	
Miscellaneous Metal Products Coatings	MACT Standard						√*						36%			1,000	
Motor Vehicle Coating	Incineration						√*						90%			8,937	
Motor Vehicle Coating	MACT Standard						√*						36%			118	
Municipal Solid Waste Landfill	Gas Collection (SCAQMD/BAAQMD)						√*						70%			700	
Municipal Waste Combustors	Selective Non-Catalytic Reduction (SNCR)					√*			X				45%			1,130	
Municipal Waste Incineration	Dry ESP-Wire Plate Type	√	√*	√									98%		40	110	250
Natural Gas Production; Compressors - Small Sources	Selective Catalytic Reduction (SCR)					√*			X				20%			1,651	
Nitric Acid Manufacturing - Small Sources	Selective Catalytic Reduction (SCR)					√*			X				97%			590	
Nitric Acid Manufacturing - Small Sources	Non-Selective Catalytic Reduction (NSCR)					√*			X				98%		510	550	710

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		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Nitric Acid Manufacturing - Small Sources	Extended Absorption					√*							95%			480	
Non-Ferrous Metals Processing - Aluminum	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	
Non-Ferrous Metals Processing - Aluminum	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	
Non-Ferrous Metals Processing - Aluminum	Fabric Filter (Mech. Shaker Type)	√	√*	√	√								99%		37	126	303
Non-Ferrous Metals Processing - Aluminum	Wet ESP - Wire Plate Type	√	√*	√	√								99%		55	220	550
Non-Ferrous Metals Processing - Aluminum	Fabric Filter (Reverse-Air Cleaned Type)	√	√*	√	√								99%		53	148	337
Non-Ferrous Metals Processing - Aluminum	Dry ESP-Wire Plate Type	√	√*	√	√								98%		40	110	250
Non-Ferrous Metals Processing - Copper	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	
Non-Ferrous Metals Processing - Copper	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	
Non-Ferrous Metals Processing - Copper	Fabric Filter (Reverse-Air Cleaned Type)	√	√*	√	√								99%		53	148	337
Non-Ferrous Metals Processing - Copper	Wet ESP - Wire Plate Type	√	√*	√	√								99%		55	220	550

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		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Non-Ferrous Metals Processing - Copper	Fabric Filter (Mech. Shaker Type)	√	√*	√	√								99%		37	126	303
Non-Ferrous Metals Processing - Copper	Dry ESP-Wire Plate Type	√	√*	√	√								98%		40	110	250
Non-Ferrous Metals Processing - Lead	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	
Non-Ferrous Metals Processing - Lead	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	
Non-Ferrous Metals Processing - Lead	Wet ESP - Wire Plate Type	√	√*	√	√								99%		55	220	550
Non-Ferrous Metals Processing - Lead	Fabric Filter (Reverse-Air Cleaned Type)	√	√*	√	√								99%		53	148	337
Non-Ferrous Metals Processing - Lead	Dry ESP-Wire Plate Type	√	√*	√	√								98%		40	110	250
Non-Ferrous Metals Processing - Lead	Fabric Filter (Mech. Shaker Type)	√	√*	√	√								99%		37	126	303
Non-Ferrous Metals Processing - Other	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	
Non-Ferrous Metals Processing - Other	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	
Non-Ferrous Metals Processing - Other	Dry ESP-Wire Plate Type	√	√*	√	√								98%		40	110	250

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		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Non-Ferrous Metals Processing - Other	Wet ESP - Wire Plate Type	√	√*	√	√								99%		55	220	550
Non-Ferrous Metals Processing - Other	Fabric Filter (Reverse-Air Cleaned Type)	√	√*	√	√								99%		53	148	337
Non-Ferrous Metals Processing - Other	Fabric Filter (Mech. Shaker Type)	√	√*	√	√								99%		37	1,260	303
Non-Ferrous Metals Processing - Zinc	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	
Non-Ferrous Metals Processing - Zinc	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	
Non-Ferrous Metals Processing - Zinc	Wet ESP - Wire Plate Type	√	√*	√	√								99%		55	220	550
Non-Ferrous Metals Processing - Zinc	Fabric Filter (Reverse-Air Cleaned Type)	√	√*	√	√								99%		53	148	337
Non-Ferrous Metals Processing - Zinc	Dry ESP-Wire Plate Type	√	√*	√	√								98%		40	110	250
Non-Ferrous Metals Processing - Zinc	Fabric Filter (Mech. Shaker Type)	√	√*	√	√								99%		37	126	303
Nonroad Diesel Engines	Heavy Duty Retrofit Program	√	√*	√	√								1%			9,500	
Nonroad Gasoline Engines	Federal Reformulated Gasoline						√*						1.4%		440	4,854	9,250

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Off-Highway Diesel Vehicles	Final Compression-Ignition (C-I) Engine Standards	√	√			√*	√			√		34%	45.5%	57%		N/A	
Off-Highway Diesel Vehicles	Final Compression-Ignition (C-I) Engine Standards	√	√			√*	√			√		49%	62%	75%		N/A	
Off-Highway Diesel Vehicles	Final Compression-Ignition (C-I) Engine Standards	√	√			√*	√			√		65%	72%	79%		N/A	
Off-Highway Diesel Vehicles	Final Compression-Ignition (C-I) Engine Standards	√	√			√*	√			√		21%	30%	59%		N/A	
Off-Highway Gasoline Vehicles	Large Spark-Ignition (S-I) Engine Standards	√	√			√*	√			√		-26%	35.5%	77%		N/A	
Off-Highway Gasoline Vehicles	Large Spark-Ignition (S-I) Engine Standards	√	√			√*	√			√		-32%	33.5%	91%		N/A	
Off-Highway Gasoline Vehicles	Large Spark-Ignition (S-I) Engine Standards	√	√			√*	√			√		-31%	29%	95%		N/A	
Off-Highway Gasoline Vehicles	Large Spark-Ignition (S-I) Engine Standards	√	√			√*	√			√		-26%	33.5%	93%		N/A	
Off-Highway Vehicles: All Terrain Vehicles (ATVs)	Recreational Gasoline ATV Standards	√	√			√	√*			√		33%	65%	97%		N/A	
Off-Highway Vehicles: All Terrain Vehicles (ATVs)	Recreational Gasoline ATV Standards	√	√			√	√*			√		33%	64%	95%		N/A	
Off-Highway Vehicles: All Terrain Vehicles (ATVs)	Recreational Gasoline ATV Standards	√	√			√	√*			√		27%	40%	73%		N/A	

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Off-Highway Vehicles: All Terrain Vehicles (ATVs)	Recreational Gasoline ATV Standards	√	√			√	√*			√		14%	24%	34%		N/A	
Off-Highway Vehicles: Motorcycles	Recreational Gasoline Off-Highway Motorcycle Standards	√	√			√	√*			√		5%	12.5%	20%		N/A	
Off-Highway Vehicles: Motorcycles	Recreational Gasoline Off-Highway Motorcycle Standards	√	√			√	√*			√		10%	25%	40%		N/A	
Off-Highway Vehicles: Motorcycles	Recreational Gasoline Off-Highway Motorcycle Standards	√	√			√	√*			√		12%	31%	50%		N/A	
Off-Highway Vehicles: Motorcycles	Recreational Gasoline Off-Highway Motorcycle Standards	√	√			√	√*			√		12%	32%	52%		N/A	
Off-Highway Vehicles: Snowmobiles	Recreational Gasoline Snowmobile Standards	√	√			X	√*			√			20%			N/A	
Off-Highway Vehicles: Snowmobiles	Recreational Gasoline Snowmobile Standards	√	√			X	√*			√			45%			N/A	
Off-Highway Vehicles: Snowmobiles	Recreational Gasoline Snowmobile Standards	√	√			X	√*			√			69%			N/A	
Off-Highway Vehicles: Snowmobiles	Recreational Gasoline Snowmobile Standards	√	√			X	√*			√			62%			N/A	
Oil and Natural Gas Production	Equipment and Maintenance						√*						37%			317	
Open Burning	Episodic Ban (Daily Only)					√*							100%			N/A	

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Open Top Degreasing	SCAQMD 1122 (VOC content limit)						√*						76%			1,248	
Open Top Degreasing	Title III MACT Standard						√*						31%			-69	
Open Top Degreasing	Airtight Degreasing System						√*						98%			9,789	
Paper and other Web Coating Operations	Permanent Total Enclosure (PTE)						√*						95			1,503	
Paper Surface Coating	Incineration						√*						78%			4,776	
Paved Roads	Vacuum Sweeping	√	√*	√	√								50.5%			485	
Pesticide Application	Reformulation - FIP Rule						√*						20%			9,300	
Petroleum Industry	Flue Gas Desulfurization (FGD)							√*					90%			N/A	
Plastics Prod-Specific; (ABS) - Small Sources	Low NOx Burner + Flue Gas Recirculation					√*							55%		1,430	3,190	3,190
Portable Gasoline Containers	OTC Portable Gas Container Rule						√*						33%			581	
Poultry Operations	Chemical Additives to Waste								√*				75%			1,014	

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Prescribed Burning	Increase Fuel Moisture	√	√*	√	√								50%			2,617	
Primary Lead Smelters - Sintering	Dual Absorption							√*					99%			N/A	
Primary Metals Industry	Flue Gas Desulfurization							√*					90%			N/A	
Primary Zinc Smelters - Sintering	Dual Absorption							√*					99%			N/A	
Process Heaters - Distillate Oil - Small Sources	Ultra Low NOx Burner					√*							74%			2,140	
Process Heaters - Distillate Oil - Small Sources	Low NOx Burner (LNB) + Selective Catalytic Reduction (SCR)					√*			X				92%		9,120	9,120	15,350
Process Heaters - Distillate Oil - Small Sources	Low NOx Burner - Selective Non-Catalytic Reduction (SNCR)					√*			X				78%		3,620	3,620	3,830
Process Heaters - Distillate Oil - Small Sources	Selective Catalytic Reduction (SCR)					√*			X				75%			9,230	
Process Heaters - Distillate Oil - Small Sources	Low NOx Burner					√*							45%			3,470	
Process Heaters - Distillate Oil - Small Sources	Low NOx Burner + Flue Gas Recirculation					√*							48%		4,250	4,250	19,540
Process Heaters - Distillate Oil - Small Sources	Selective Non-Catalytic Reduction (SNCR)					√*			X				60%			3,180	

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Process Heaters - LPG - Small Sources	Selective Catalytic Reduction (SCR)					√*			X				75%			9,230	
Process Heaters - LPG - Small Sources	Low NOx Burner (LNB) + Selective Catalytic Reduction (SCR)					√*			X				92%		9,120	9,120	15,350
Process Heaters - LPG - Small Sources	Low NOx Burner					√*							45%			3,470	
Process Heaters - LPG - Small Sources	Low NOx Burner (LNB) + SNCR					√*			X				78%		3,620	3,620	3,830
Process Heaters - LPG - Small Sources	Ultra Low NOx Burner					√*							74%			2,140	
Process Heaters - LPG - Small Sources	Selective Non-Catalytic Reduction (SNCR)					√*			X				60%			3,180	
Process Heaters - LPG - Small Sources	Low NOx Burner + Flue Gas Recirculation					√*							48%		4,250	4,250	19,540
Process Heaters - Natural Gas - Small Sources	Selective Non-Catalytic Reduction (SNCR)					√*			X				60%			2,850	
Process Heaters - Natural Gas - Small Sources	Low NOx Burner + Flue Gas Recirculation					√*							55%		3,190	3,190	15,580
Process Heaters - Natural Gas - Small Sources	Low NOx Burner					√*							50%			2,200	
Process Heaters - Natural Gas - Small Sources	Low NOx Burner (LNB) + SNCR					√*			X				80%		3,520	3,520	6,600

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Process Heaters - Natural Gas - Small Sources	Selective Catalytic Reduction (SCR)					√*			X				75%			12,040	
Process Heaters - Natural Gas - Small Sources	Ultra Low NOx Burner					√*							75%			1,500	
Process Heaters - Natural Gas - Small Sources	Low NOx Burner (LNB) + Selective Catalytic Reduction (SCR)					√*			X				88%		11,560	11,560	27,910
Process Heaters - Other Fuel - Small Sources	Selective Non-Catalytic Reduction (SNCR)					√*			X				60%			1,930	
Process Heaters - Other Fuel - Small Sources	Low NOx Burner (LNB) + Selective Catalytic Reduction (SCR)					√*			X				91%		5,420	5,420	7,680
Process Heaters - Other Fuel - Small Sources	Selective Catalytic Reduction (SCR)					√*			X				75%			5,350	
Process Heaters - Other Fuel - Small Sources	Low NOx Burner (LNB) + SNCR					√*			X				75%		2,230	2,300	2,860
Process Heaters - Other Fuel - Small Sources	Ultra Low NOx Burner					√*							73%			1,290	
Process Heaters - Other Fuel - Small Sources	Low NOx Burner					√*							37%			2,520	
Process Heaters - Other Fuel - Small Sources	Low NOx Burner + Flue Gas Recirculation					√*							34%			3,490	
Process Heaters - Process Gas - Small Sources	Low NOx Burner + Flue Gas Recirculation					√*							55%		1,430	3,190	3,190

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Process Heaters - Process Gas - Small Sources	Low NOx Burner (LNB) + Selective Catalytic Reduction (SCR)					√*			X				88%		11,560	11,560	27,910
Process Heaters - Process Gas - Small Sources	Low NOx Burner (LNB) + Selective Reduction SNCR					√*			X				80%		3,520	3,520	6,600
Process Heaters - Process Gas - Small Sources	Selective Catalytic Reduction (SCR)					√*			X				75%			12,040	
Process Heaters - Process Gas - Small Sources	Selective Non-Catalytic Reduction (SNCR)					√*			X				60%			2,850	
Process Heaters - Process Gas - Small Sources	Low NOx Burner					√*							50%			2,200	
Process Heaters - Process Gas - Small Sources	Ultra Low NOx Burner					√*							75%			1,500	
Process Heaters - Residual Oil - Small Sources	Low NOx Burner (LNB) + Selective Catalytic Reduction (SCR)					√*			X				91%		5,420	5,420	7,680
Process Heaters - Residual Oil - Small Sources	Ultra Low NOx Burner					√*							73%			1,290	
Process Heaters - Residual Oil - Small Sources	Low NOx Burner					√*							37%			2,520	
Process Heaters - Residual Oil - Small Sources	Low NOx Burner + Flue Gas Recirculation					√*							34%			3,490	
Process Heaters - Residual Oil - Small Sources	Selective Non-Catalytic Reduction (SNCR)					√*			X				60%			1,930	

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Process Heaters - Residual Oil - Small Sources	Selective Catalytic Reduction (SCR)					√*			X				75%			5,350	
Process Heaters - Residual Oil - Small Sources	Low NOx Burner (LNB) + SCR					√*			X				75%		2,230	2,300	2,860
Process Heaters (Oil and Gas Production)	Flue Gas Desulfurization							√*					90%			N/A	
Product and Packaging Rotogravure and Screen Printing	Permanent Total Enclosure (PTE)						√*						95			12,770	
Publication Rotogravure Printing	Permanent Total Enclosure (PTE)						√*						95			2,422	
Pulp and Paper Industry (Sulfate Pulping)	Flue Gas Desulfurization							√*					90%			N/A	
Residential Natural Gas	Water Heater Replacement					√*							7%			N/A	
Residential Natural Gas	Water Heater + LNB Space Heaters					√*							7%			1,230	
Residential Wood Combustion	Education and Advisory Program	√	√*	√	√								50%			1,320	
Residential Wood Stoves	NSPS compliant Wood Stoves	√*	√*										98%			2,000	
Residual Oil (Commercial/Institutional Boilers)	Wet Flue Gas Desulfurization							√*					90%		2,295	3,489	4,524

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Residual Oil (Commercial/Institutional Boilers)	Flue Gas Desulfurization							√*					90%			N/A	
Residual Oil (Industrial Boilers)	Flue Gas Desulfurization							√*					90%			N/A	
Rich-Burn Stationary Reciprocating Internal Combustion Engines	Non-selective catalytic reduction					√*							90%			342	
Rich-Burn Stationary Reciprocating Internal Combustion Engines	Non-selective catalytic reduction					√*							90%			342	
Rich-Burn Stationary Reciprocating Internal Combustion Engines (RICE)	Non-selective catalytic reduction (NSCR)					√*	√			√			90%			342	
Rubber and Plastics Manufacturing	SCAQMD - Low VOC						√*						60%			1,020	
Sand/Gravel; Dryer - Small Sources	Low NOx Burner + Flue Gas Recirculation					√*							55%		1,430	3,190	3,190
Secondary Aluminum Production; Smelting Furnaces	Low NOx Burner					√*							50%			570	
Secondary Metal Production	Flue Gas Desulfurization							√*					90%			N/A	
Solid Waste Disposal; Government; Other	Selective Non-Catalytic Reduction (SNCR)					√*			X				45%			1,130	
Space Heaters - Distillate Oil - Small Sources	Low NOx Burner					√*							50%			1,180	

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Space Heaters - Distillate Oil - Small Sources	Low NOx Burner + Flue Gas Recirculation					√*							60%		1,090	2,490	2,490
Space Heaters - Distillate Oil - Small Sources	Selective Catalytic Reduction (SCR)					√*			X				80%		2,780	2,780	3,570
Space Heaters - Distillate Oil - Small Sources	Selective Non-Catalytic Reduction (SNCR)					√*			X				50%		3,470	4,640	4,640
Space Heaters - Natural Gas - Small Sources	Selective Non-Catalytic Reduction (SNCR)					√*			X				50%		2,900	3,870	3,870
Space Heaters - Natural Gas - Small Sources	Selective Catalytic Reduction (SCR)					√*			X				80%		2,230	2,230	2,860
Space Heaters - Natural Gas - Small Sources	Low NOx Burner					√*							50%			820	
Space Heaters - Natural Gas - Small Sources	Oxygen Trim + Water Injection					√*							65%			680	
Space Heaters - Natural Gas - Small Sources	Low NOx Burner + Flue Gas Recirculation					√*							60%		2,470	2,560	2,560
Stage II Service Stations	Low Pressure/Vacuum Relief Valve						√*						91.6%		930	1,080	1,230
Stage II Service Stations - Underground Tanks	Low Pressure/Vacuum Relief Valve						√*						73%		930	1,080	1,230
Starch Manufacturing; Combined Operation - Small Sources	Low NOx Burner + Flue Gas Recirculation					√*							55%		1,430	3,190	3,190

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Steam Generating Unit-Coal/Oil	Flue Gas Desulfurization							√*					90%			N/A	
Steel Foundries; Heat Treating	Low NOx Burner					√*							50%			570	
Steel Production; Soaking Pits	Low NOx Burner + Flue Gas Recirculation					√*							60%		250	750	750
Sulfate Pulping - Recovery Furnaces - Small Sources	Low NOx Burner					√*							50%			820	
Sulfate Pulping - Recovery Furnaces - Small Sources	Selective Non-Catalytic Reduction (SNCR)					√*			X				50%		2,900	3,870	3,870
Sulfate Pulping - Recovery Furnaces - Small Sources	Selective Catalytic Reduction (SCR)					√*			X				80%		2,230	2,230	2,860
Sulfate Pulping - Recovery Furnaces - Small Sources	Oxygen Trim + Water Injection					√*							65%			680	
Sulfate Pulping - Recovery Furnaces - Small Sources	Low NOx Burner + Flue Gas Recirculation					√*							60%		2,470	2,560	2,560
Sulfur Recovery Plants - Elemental Sulfur	Amine Scrubbing + Flue Gas Desulfurization							√*					99.8%			N/A	
Sulfur Recovery Plants - Elemental Sulfur	Amine Scrubbing + Flue Gas Desulfurization							√*					99.7%			N/A	
Sulfur Recovery Plants - Elemental Sulfur	Amine Scrubbing							√*					98.4%			N/A	

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
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		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Sulfur Recovery Plants - Elemental Sulfur	Amine Scrubbing							√*					97.8%			N/A	
Sulfur Recovery Plants - Elemental Sulfur	Amine Scrubbing							√*					97.1%			N/A	
Sulfur Recovery Plants - Elemental Sulfur	Flue Gas Desulfurization							√*					90%			N/A	
Sulfur Recovery Plants - Elemental Sulfur	Amine Scrubbing + Flue Gas Desulfurization							√*					99.8%			N/A	
Sulfur Recovery Plants - Sulfur Removal	Flue Gas Desulfurization							√*					90%			N/A	
Sulfuric Acid Plants - Contact Absorbers	Increase Absorption Efficiency from Existing to NSPS Level (99.7%) + Flue Gas Desulfurization							√*					95%			N/A	
Sulfuric Acid Plants - Contact Absorbers	Increase Absorption Efficiency from Existing to NSPS Level (99.7%)							√*					75%			N/A	
Sulfuric Acid Plants - Contact Absorbers	Flue Gas Desulfurization							√*					90%			N/A	
Sulfuric Acid Plants - Contact Absorbers	Increase Absorption Efficiency from Existing to NSPS Level (99.7%) + Flue Gas Desulfurization							√*					85%			N/A	
Sulfuric Acid Plants - Contact Absorbers	Increase Absorption Efficiency from Existing to NSPS Level (99.7%)							√*					90%			N/A	
Sulfuric Acid Plants - Contact Absorbers	Increase Absorption Efficiency from Existing to NSPS Level (99.7%) + Flue Gas Desulfurization							√*					90%			N/A	

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Sulfuric Acid Plants - Contact Absorbers	Increase Absorption Efficiency from Existing to NSPS Level (99.7%)							√*					95%			N/A	
Sulfuric Acid Plants - Contact Absorbers	Increase Absorption Efficiency from Existing to NSPS Level (99.7%) + Flue Gas Desulfurization							√*					75%			N/A	
Sulfuric Acid Plants - Contact Absorbers	Increase Absorption Efficiency from Existing to NSPS Level (99.7%)							√*					85%			N/A	
Surface Coat Oper; Coating Oven Htr; Nat Gas - Small Sources	Low NOx Burner					√*			X				50%			2,200	
Traffic Markings	South Coast Phase II						√*						47%			4,017	
Traffic Markings	AIM Coating Federal Rule						√*						20%			228	
Traffic Markings	South Coast Phase III						√*						73%			1,059	
Traffic Markings	South Coast Phase I						√*						34%		8,600	1,443	12,800
Unpaved Roads	Chemical Stabilization	√	√*	√									37.5%			2,753	
Unpaved Roads	Hot Asphalt Paving	√	√*	√	√								67.5%			537	
Utility Boiler - Coal/Tangential	Low Nox Coal-and-Air Nozzles with cross-Coupled Overfire Air (LNC1)					√*							33%			N/A	

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		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Utility Boiler - Coal/Tangential	Low Nox Coal-and-Air Nozzles with separated Overfire Air (LNC2)					√*							48%			N/A	
Utility Boiler - Coal/Tangential	Low Nox Coal-and-Air Nozzles with Close-Coupled and Separated Overfire Air (LNC3)					√*							58%			N/A	
Utility Boiler - Coal/Tangential	Low Nox Coal-and-Air Nozzles with cross-Coupled Overfire Air (LNC1)					√*							43%			N/A	
Utility Boiler - Coal/Tangential	Low Nox Coal-and-Air Nozzles with separated Overfire Air (LNC2)					√*							38%			N/A	
Utility Boiler - Coal/Tangential	Low Nox Coal-and-Air Nozzles with Close-Coupled and Separated Overfire Air (LNC3)					√*							53%			N/A	
Utility Boiler - Coal/Tangential	Selective Non-Catalytic Reduction (SNCR)					√*			X				35%			N/A	
Utility Boiler - Coal/Tangential	Selective Catalytic Reduction (SCR)					√*			X		√		90% (Hg 95%)			N/A	
Utility Boiler - Coal/Tangential	Natural Gas Reburn (NGR)					√*							50%			N/A	
Utility Boiler - Coal/Wall	Low Nox Burner with Overfire Air					√*							56%			N/A	
Utility Boiler - Coal/Wall	Low Nox Burner without Overfire Air					√*							41			N/A	
Utility Boiler - Coal/Wall	Low Nox Burner without Overfire Air					√*							40%			N/A	

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Utility Boiler - Coal/Wall	Low Nox Burner with Overfire Air					√*							55%			N/A	
Utility Boiler - Coal/Wall	Selective Catalytic Reduction (SCR)					√*			X				90%			N/A	
Utility Boiler - Coal/Wall	Selective Non-Catalytic Reduction (SNCR)					√*			X				35%			N/A	
Utility Boiler - Coal/Wall	Natural Gas Reburn (NGR)					√*							50%			N/A	
Utility Boiler - Cyclone	Natural Gas Reburn (NGR)					√*							50%			N/A	
Utility Boiler - Cyclone	Selective Non-Catalytic Reduction (SNCR)					√*			X				35%			N/A	
Utility Boiler - Cyclone	Selective Catalytic Reduction (SCR)					√*			X				80%			N/A	
Utility Boiler - Oil-Gas/Tangential	Selective Non-Catalytic Reduction (SNCR)					√*			X				50%			N/A	
Utility Boiler - Oil-Gas/Tangential	Selective Catalytic Reduction (SCR)					√*			X				80%			N/A	
Utility Boiler - Oil-Gas/Tangential	Natural Gas Reburn (NGR)					√*							50%			N/A	
Utility Boiler - Oil-Gas/Wall	Selective Non-Catalytic Reduction (SNCR)					√*			X				50%			N/A	

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Utility Boiler - Oil-Gas/Wall	Natural Gas Reburn (NGR)					√*							50%			N/A	
Utility Boiler - Oil-Gas/Wall	Selective Catalytic Reduction (SCR)					√*			X				80%			N/A	
Utility Boilers - Coal	Fabric Filter (Mech. Shaker Type)	√	√*	√	√						√		99.5%		37	126	303
Utility Boilers - Coal	Fabric Filter	√	√*	√	√						√		95% (Hg 80%)			N/A	
Utility Boilers - Coal	Fabric Filter (Reverse-Air Cleaned Type)	√	√*	√	√						√		99%		53	148	337
Utility Boilers - Coal	Dry ESP-Wire Plate Type	√	√*	√	√						√	(Hg 3%)	98% (Hg 20%)	(Hg 36%)	40	110	250
Utility Boilers - Coal	Fabric Filter (Pulse Jet Type)	√	√*	√	√						√		99%		42	117	266
Utility Boilers - Coal-Fired	Fuel Switching - High-Sulfur Coal to Low-Sulfur Coal	√	√					√*					60%		113	140	167
Utility Boilers - Coal-Fired	Repowering to IGCC					√		√*			√		99%			N/A	
Utility Boilers - Coal-Fired	Coal Washing	√	√					√*			√		40%		70	320	563
Utility Boilers - Gas/Oil	Fabric Filter	√	√*	√	√						√		95%			N/A	

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Utility Boilers - High Sulfur Content	Flue Gas Desulfurization (Wet Scrubber Type)							√*			√	(Hg 29%)	90% (Hg 64%)	(Hg 98%)		N/A	
Utility Boilers - Medium Sulfur Content	Flue Gas Desulfurization (Wet Scrubber Type)							√*			√	(Hg 29%)	90% (Hg 64%)	(Hg 98%)		N/A	
Utility Boilers - Very High Sulfur Content	Flue Gas Desulfurization (Wet Scrubber Type)							√*			√		90%			N/A	
Wood Furniture Surface Coating	MACT Standard						√*						30%			446	
Wood Furniture Surface Coating	New CTG						√*						47%		462	967	22,100
Wood Furniture Surface Coating	Add-On Controls						√*					67%	75%	98%	468	20,000	22,100
Wood Product Surface Coating	SCAQMD Rule 1104						√*						53%			881	
Wood Product Surface Coating	Incineration						√*						86%			4,202	
Wood Product Surface Coating	MACT Standard						√*						30%			446	
Wood Pulp & Paper	Wet ESP - Wire Plate Type	√	√*	√	√								99%		55	220	550
Wood Pulp & Paper	Dry ESP-Wire Plate Type	√	√*	√	√								98%		40	110	250

APPENDIX B: CONTROL MEASURE SUMMARY LIST - BY POLLUTANT

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Appendix B Control Measure Summary List by Source Category (1999 Baseline) - Sorted alphabetically by Pollutant and Source Category

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Cattle Feedlots	Chemical Additives to Waste								√*				50%			228	
Hog Operations	Chemical Additives to Waste								√*				50%			73	
Poultry Operations	Chemical Additives to Waste								√*				75%			1,014	
Agricultural Burning	Seasonal Ban (Ozone Season Daily)					√*							100%			N/A	
Ammonia - Natural Gas - Fired Reformers - Small Sources	Oxygen Trim + Water Injection					√*							65%			680	
Ammonia - Natural Gas - Fired Reformers - Small Sources	Low NOx Burner					√*							50%			820	
Ammonia - Natural Gas - Fired Reformers - Small Sources	Selective Non-Catalytic Reduction (SNCR)					√*			X				50%		2,900	3,870	3,870
Ammonia - Natural Gas - Fired Reformers - Small Sources	Selective Catalytic Reduction (SCR)					√*			X				80%		2,230	2,230	2,860
Ammonia - Natural Gas - Fired Reformers - Small Sources	Low NOx Burner (LNB) + Flue Gas Recirculation (FGR)					√*							60%		2,470	2,560	2,560
Ammonia Products; Feedstock Desulfurization - Small Sources	Low NOx Burner + Flue Gas Recirculation					√*							60%		2,470	2,560	2,560
Asphaltic Conc; Rotary Dryer; Conv Plant - Small Sources	Low NOx Burner					√*							50%			2,200	

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
By-Product Coke Manufacturing; Oven Underfiring	Selective Non-Catalytic Reduction (SNCR)					√*			X				60%			1,640	
Cement Kilns	Biosolid Injection					√*							23%			310	
Cement Manufacturing - Dry	Low NOx Burner					√*							25%		300	440	620
Cement Manufacturing - Dry	Mid-Kiln Firing					√*							25%		-460	55	730
Cement Manufacturing - Dry	Selective Catalytic Reduction (SCR)					√*			X				80%			3,370	
Cement Manufacturing - Dry	Selective Non-Catalytic Reduction (SNCR) Ammonia Based					√*			X				50%			850	
Cement Manufacturing - Dry	Selective Non-Catalytic Reduction (SNCR) Urea Based					√*			X				50%			770	
Cement Manufacturing - Wet	Low NOx Burner					√*							25%		300	440	620
Cement Manufacturing - Wet	Mid-Kiln Firing					√*							25%		-460	55	730
Cement Manufacturing - Wet - Large Sources	Selective Catalytic Reduction (SCR)					√*			X				80%			2,880	
Cement Manufacturing - Wet - Small Sources	Selective Catalytic Reduction (SCR)					√*			X				80%			2,880	

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Ceramic Clay Manufacturing; Drying - Small Sources	Low NOx Burner					√*							50%			2,200	
Coal Cleaning-Thrml Dryer; Fluidized Bed - Small Sources	Low NOx Burner					√*							50%			1,460	
Coal-fired Plants with Production Capacities>100MW	Combustion Optimization					√*							20%			-25	
Combustion Turbines - Jet Fuel - Small Sources	Selective Catalytic Reduction (SCR) + Water Injection					√*							90%			2,300	
Combustion Turbines - Jet Fuel - Small Sources	Water Injection					√*							68%			1,290	
Combustion Turbines - Natural Gas - Large Sources	Dry Low NOx Combustors					√*							50%		100	100	140
Combustion Turbines - Natural Gas - Small Sources	Water Injection					√*							76%			1,510	
Combustion Turbines - Natural Gas - Small Sources	Selective Catalytic Reduction (SCR) + Steam Injection					√*			X				95%		2,010	2,010	8,960
Combustion Turbines - Natural Gas - Small Sources	Selective Catalytic Reduction (SCR) + Low NOx Burner (LNB)					√*			X				94%		2,570	2,570	19,120
Combustion Turbines - Natural Gas - Small Sources	Dry Low NOx Combustors					√*							84%		490	490	540
Combustion Turbines - Natural Gas - Small Sources	Steam Injection					√*							80%			1,040	

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Combustion Turbines - Natural Gas - Small Sources	Selective Catalytic Reduction (SCR) + Water Injection					√*							95%			2,730	
Combustion Turbines - Oil - Small Sources	Selective Catalytic Reduction (SCR) + Water Injection					√*							90%			2,300	
Combustion Turbines - Oil - Small Sources	Water Injection					√*							68%			1,290	
Commercial/Institutional - Natural Gas	Water Heaters + LNB Space Heaters					√*							7%			1,230	
Commercial/Institutional - Natural Gas	Water Heater Replacement					√*							7%			N/A	
Commercial/Institutional Incinerators	Selective Non-Catalytic Reduction (SNCR)					√*			X				45%			1,130	
Conv Coating of Prod; Acid Cleaning Bath - Small Sources	Low NOx Burner					√*							50%			2,200	
Diesel Locomotives	Selective Catalytic Reduction (SCR)					√*							72%			1,400	
Fiberglass Manufacture; Textile-Type; Recuperative Furnaces	Low NOx Burner					√*							40%			1,690	
Fluid Catalytic Cracking Units - Small Sources	Low NOx Burner + Flue Gas Recirculation					√*							55%		1,430	3,190	3,190
Fuel Fired Equipment - Process Heaters	Low Nox Burner + Flue Gas Recirculation					√*							50%			570	

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Fuel Fired Equipment; Furnaces; Natural Gas	Low NOx Burner					√*							50%			570	
Glass Manufacturing - Containers	Selective Catalytic Reduction (SCR)					√*			X				75%			2,200	
Glass Manufacturing - Containers	Electric Boost					√*							10%			7,150	
Glass Manufacturing - Containers	Cullet Preheat					√*							25%			940	
Glass Manufacturing - Containers	Low NOx Burner					√*							40%			1,690	
Glass Manufacturing - Containers	Selective Non-Catalytic Reduction (SNCR)					√*			X				40%			1,770	
Glass Manufacturing - Containers	OXY-Firing					√*							85%			4,590	
Glass Manufacturing - Flat	Low NOx Burner					√*							40%			700	
Glass Manufacturing - Flat	OXY-Firing					√*							85%			1,900	
Glass Manufacturing - Flat	Electric Boost					√*							10%			2,320	
Glass Manufacturing - Flat - Large Sources	Selective Non-Catalytic Reduction (SNCR)					√*			X				40%			740	

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Glass Manufacturing - Flat - Large Sources	Selective Catalytic Reduction (SCR)					√*			X				75%			710	
Glass Manufacturing - Flat - Small Sources	Selective Catalytic Reduction (SCR)					√*			X				75%			710	
Glass Manufacturing - Flat - Small Sources	Selective Non-Catalytic Reduction (SNCR)					√*			X				40%			740	
Glass Manufacturing - Pressed	OXY-Firing					√*							85%			3,900	
Glass Manufacturing - Pressed	Selective Catalytic Reduction (SCR)					√*			X				75%			2,530	
Glass Manufacturing - Pressed	Low NOx Burner					√*							40%			1,500	
Glass Manufacturing - Pressed	Cullet Preheat					√*							25%			810	
Glass Manufacturing - Pressed	Electric Boost					√*							10%			8,760	
Glass Manufacturing - Pressed	Selective Non-Catalytic Reduction (SNCR)					√*			X				40%			1,640	
Highway Vehicles - Gasoline Engine	Low Reid Vapor Pressure (RVP) Limit in Ozone Season					√	√*			√		0.1%	5.5%	11.1%	125	1,548	25,671
Highway Vehicles - Heavy Duty and Diesel-Fueled Vehicles	Heavy Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Controls	√	√			√*	√	√		√			76%			10,561	

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Highway Vehicles - Heavy Duty and Diesel-Fueled Vehicles	Heavy Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Controls	√	√			√*	√	√		√			19%			9,301	
Highway Vehicles - Heavy Duty and Diesel-Fueled Vehicles	Heavy Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Controls	√	√			√*	√	√		√			44%			10,561	
Highway Vehicles - Heavy Duty and Diesel-Fueled Vehicles	Heavy Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Controls	√	√			√*	√	√		√			61%			10,561	
Highway Vehicles - Heavy Duty Diesel Engines	Voluntary Diesel Retrofit Program: Selective Catalytic Reduction	√	√			√*	√	√		√			19.26%			50,442	
Highway Vehicles - Light Duty and Gasoline-Fueled Vehicles	Tier 2 Motor Vehicle Emissions and Gasoline Sulfur Controls	√	√			√*	√	√		√		28%	34%	40%		6,297	
Highway Vehicles - Light Duty and Gasoline-Fueled Vehicles	Tier 2 Motor Vehicle Emissions and Gasoline Sulfur Controls	√	√			√*	√	√		√		74%	83%	92%		6,297	
Highway Vehicles - Light Duty and Gasoline-Fueled Vehicles	Tier 2 Motor Vehicle Emissions and Gasoline Sulfur Controls	√	√			√*	√	√		√		52%	64.5%	77%		6,297	
Highway Vehicles - Light Duty and Gasoline-Fueled Vehicles	Tier 2 Motor Vehicle Emissions and Gasoline Sulfur Controls	√	√			√*	√	√		√		43%	54.5%	66%		6,297	
Highway Vehicles - Light Duty Gasoline Engines	High Enhanced Inspection and Maintenance (I/M) Program					√*	√			√		0.4%	6.5%	13.4%	3,900	7,949	218,369
IC Engines - Gas	L-E (Low Speed)					√*							87%			176	
IC Engines - Gas - Small Sources	Selective Catalytic Reduction (SCR)					√*							90%			2,769	

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
IC Engines - Gas, Diesel, LPG - Small Sources	Ignition Retard					√*							25%			770	
IC Engines - Gas, Diesel, LPG - Small Sources	Selective Catalytic Reduction (SCR)					√*							80%			2,340	
ICI Boilers - Coal/Cyclone - Large Sources	Coal Reburn					√*							50%			300	
ICI Boilers - Coal/Cyclone - Small Sources	Natural Gas Reburn (NGR)					√*							55%			1,570	
ICI Boilers - Coal/Cyclone - Small Sources	Selective Non-Catalytic Reduction (SNCR)					√*			X				35%			840	
ICI Boilers - Coal/Cyclone - Small Sources	Coal Reburn					√*							50%			1,570	
ICI Boilers - Coal/Cyclone - Small Sources	Selective Catalytic Reduction (SCR)					√*							80%			820	
ICI Boilers - Coal/FBC - Large Sources	Selective Non-Catalytic Reduction (SNCR) Urea Based					√*			X				40%			670	
ICI Boilers - Coal/FBC - Small Sources	Selective Non-Catalytic Reduction (SNCR) Urea Based					√*			X				75%			900	
ICI Boilers - Coal/Stoker - Small Sources	Selective Non-Catalytic Reduction (SNCR)					√*			X				40%			817	
ICI Boilers - Coal/Stoker - Small Sources	Selective Non-Catalytic Reduction (SNCR)					√*			X				40%		873	1,015	1,015

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
ICI Boilers - Coal/Wall - Large Sources	Low NOx Burner					√*							50%			1,090	
ICI Boilers - Coal/Wall - Large Sources	Selective Non-Catalytic Reduction (SNCR)					√*			X				40%			840	
ICI Boilers - Coal/Wall - Large Sources	Selective Catalytic Reduction (SCR)					√*			X				70%			1,070	
ICI Boilers - Coal/Wall - Small Sources	Low NOx Burner					√*							50%			1,460	
ICI Boilers - Coal/Wall - Small Sources	Selective Non-Catalytic Reduction (SNCR)					√*			X				40%		400	1,040	1,040
ICI Boilers - Coal/Wall - Small Sources	Selective Catalytic Reduction (SCR)					√*							70%			1,260	
ICI Boilers - Coke - Small Sources	Selective Non-Catalytic Reduction (SNCR)					√*			X				40%		400	1,040	1,040
ICI Boilers - Coke - Small Sources	Selective Catalytic Reduction (SCR)					√*			X				70%			1,260	
ICI Boilers - Coke - Small Sources	Low NOx Burner					√*							50%			1,460	
ICI Boilers - Distillate Oil - Large Sources	Selective Non-Catalytic Reduction (SNCR)					√*			X				50%			1,890	
ICI Boilers - Distillate Oil - Small Sources	Low NOx Burner					√*							50%			1,180	

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
ICI Boilers - Distillate Oil - Small Sources	Low NOx Burner + Flue Gas Recirculation					√*							60%		1,090	2,490	2,490
ICI Boilers - Distillate Oil - Small Sources	Selective Non-Catalytic Reduction (SNCR)					√*			X				50%		3,470	4,640	4,640
ICI Boilers - Distillate Oil - Small Sources	Selective Catalytic Reduction (SCR)					√*			X				80%		2,780	2,780	3,570
ICI Boilers - Liquid Waste	Selective Catalytic Reduction (SCR)					√*			X				80%		1,480	1,480	1,910
ICI Boilers - Liquid Waste - Small Sources	Low NOx Burner					√*							50%			400	
ICI Boilers - Liquid Waste - Small Sources	Low NOx Burner + Flue Gas Recirculation					√*							60%		1,120	1,120	1,080
ICI Boilers - Liquid Waste - Small Sources	Selective Non-Catalytic Reduction (SNCR)					√*			X				50%		1,940	2,580	2,580
ICI Boilers - LPG - Small Sources	Selective Catalytic Reduction (SCR)					√*			X				80%		2,780	2,780	3,570
ICI Boilers - LPG - Small Sources	Selective Non-Catalytic Reduction (SNCR)					√*			X				50%		3,470	4,640	4,640
ICI Boilers - LPG - Small Sources	Low NOx Burner					√*							50%			1,180	
ICI Boilers - LPG - Small Sources	Low NOx Burner + Flue Gas Recirculation					√*							60%		1,090	2,490	2,490

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
ICI Boilers - MSW/Stoker - Small Sources	Selective Non-Catalytic Reduction (SNCR) Urea Based					√*			X				55%			1,690	
ICI Boilers - Natural Gas - Large Sources	Selective Non-Catalytic Reduction (SNCR)					√*			X				50%			1,570	
ICI Boilers - Natural Gas - Small Sources	Oxygen Trim + Water Injection					√*							65%			680	
ICI Boilers - Natural Gas - Small Sources	Selective Catalytic Reduction (SCR)					√*			X				80%		2,230	2,230	2,860
ICI Boilers - Natural Gas - Small Sources	Selective Non-Catalytic Reduction (SNCR)					√*			X				50%		2,900	3,870	3,870
ICI Boilers - Natural Gas - Small Sources	Low NOx Burner + Flue Gas Recirculation					√*							60%		2,470	2,560	2,560
ICI Boilers - Natural Gas - Small Sources	Low NOx Burner					√*							50%			820	
ICI Boilers - Process Gas - Small Sources	Low NOx Burner					√*							50%			820	
ICI Boilers - Process Gas - Small Sources	Oxygen Trim + Water Injection					√*							65%			680	
ICI Boilers - Process Gas - Small Sources	Selective Catalytic Reduction (SCR)					√*			X				80%		2,230	2,230	2,860
ICI Boilers - Process Gas - Small Sources	Low NOx Burner + Flue Gas Recirculation					√*							60%		2,470	2,560	2,560

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
ICI Boilers - Residual Oil - Large Sources	Selective Non-Catalytic Reduction (SNCR)					√*			X				50%			1,050	
ICI Boilers - Residual Oil - Small Sources	Selective Catalytic Reduction (SCR)					√*			X				80%		1,480	1,480	1,910
ICI Boilers - Residual Oil - Small Sources	Low NOx Burner + Flue Gas Recirculation					√*							60%		1,120	1,120	1,080
ICI Boilers - Residual Oil - Small Sources	Selective Non-Catalytic Reduction (SNCR)					√*			X				50%		1,940	2,580	2,580
ICI Boilers - Residual Oil - Small Sources	Low NOx Burner					√*							50%			400	
ICI Boilers - Wood/Bark/Stoker - Large Sources	Selective Non-Catalytic Reduction (SNCR) Urea Based					√*			X				55%			1,190	
ICI Boilers - Wood/Bark/Stoker - Small Sources	Selective Non-Catalytic Reduction (SNCR) Urea Based					√*			X				55%			1,440	
Industrial Coal Combustion	RACT to 50 tpy (LNB)					√*							21%			1,350	
Industrial Coal Combustion	RACT to 25 tpy (LNB)					√*							21%			1,350	
Industrial Incinerators	Selective Non-Catalytic Reduction (SNCR)					√*			X				45%			1,130	
Industrial Natural Gas Combustion	RACT to 50 tpy (LNB)					√*							31%			770	

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Industrial Natural Gas Combustion	RACT to 25 tpy (LNB)					√*							31%			770	
Industrial Oil Combustion	RACT to 50 tpy (LNB)					√*							36%			1,180	
Industrial Oil Combustion	RACT to 25 tpy (LNB)					√*							36%			1,180	
In-Proc; Process Gas; Coke Oven/Blast Ovens	Low NOx Burner + Flue Gas Recirculation					√*							55%		1,430	3,190	3,190
In-Process Fuel Use - Bituminous Coal - Small Sources	Selective Non-Catalytic Reduction (SNCR)					√*			X				40%			1,260	
In-Process Fuel Use; Natural Gas - Small Sources	Low NOx Burner					√*							50%			2,200	
In-Process Fuel Use; Residual Oil - Small Sources	Low NOx Burner					√*							37%			2,520	
In-Process; Bituminous Coal; Cement Kilns	Selective Non-Catalytic Reduction (SNCR) Urea Based					√*			X				50%			770	
In-Process; Bituminous Coal; Lime Kilns	Selective Non-Catalytic Reduction (SNCR) Urea Based					√*			X				50%			770	
In-Process; Process Gas; Coke Oven Gas	Low NOx Burner					√*							50%			2,200	
Internal Combustion Engines - Gas	L-E (Medium Speed)					√*							87%			380	

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Internal Combustion Engines - Gas - Large Sources	Air/Fuel + Ignition Retard					√*							30%		150	460	460
Internal Combustion Engines - Gas - Large Sources	Air/Fuel Ratio Adjustment					√*							20%			380	
Internal Combustion Engines - Gas - Large Sources	Ignition Retard					√*							20%			550	
Internal Combustion Engines - Gas - Small Sources	Air/Fuel + Ignition Retard					√*							30%		270	1,440	1,440
Internal Combustion Engines - Gas - Small Sources	Air/Fuel Ratio Adjustment					√*							20%			1,570	
Internal Combustion Engines - Gas - Small Sources	Ignition Retard					√*							20%			1,020	
Internal Combustion Engines - Oil - Small Sources	Ignition Retard					√*							25%			770	
Internal Combustion Engines - Oil - Small Sources	Selective Catalytic Reduction (SCR)					√*			X				80%			2,340	
Iron & Steel Mills - Annealing	Low NOx Burner (LNB) + SCR					√*			X				80%		1,320	1,720	1,720
Iron & Steel Mills - Annealing	Selective Non-Catalytic Reduction (SNCR)					√*			X				60%			1,640	
Iron & Steel Mills - Annealing	Low NOx Burner					√*							50%			570	

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Iron & Steel Mills - Annealing	Low NOx Burner + Flue Gas Recirculation					√*							60%		250	750	750
Iron & Steel Mills - Annealing - Small Sources	Selective Catalytic Reduction (SCR)					√*			X				85%			3,830	
Iron & Steel Mills - Annealing - Small Sources	Low NOx Burner (LNB) + Selective Catalytic Reduction (SCR)					√*			X				90%		3,720	4,080	4,080
Iron & Steel Mills - Galvanizing	Low NOx Burner					√*							50%			490	
Iron & Steel Mills - Galvanizing	Low NOx Burner + Flue Gas Recirculation					√*							60%		190	580	580
Iron & Steel Mills - Reheating	Low NOx Burner + Flue Gas Recirculation					√*							77%		150	380	380
Iron & Steel Mills - Reheating	Low NOx Burner					√*							66%			300	
Iron & Steel Mills - Reheating	Low Excess Air (LEA)					√*							13%			1,320	
Iron Production; Blast Furnaces; Blast Heating Stoves	Low NOx Burner + Flue Gas Recirculation					√*							77%			380	
Lime Kilns	Selective Non-Catalytic Reduction (SNCR) Urea Based					√*			X				50%			770	
Lime Kilns	Selective Catalytic Reduction (SCR)					√*			X				80%			3,370	

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Lime Kilns	Selective Non-Catalytic Reduction (SNCR) Ammonia Based					√*			X				50%			850	
Lime Kilns	Mid-Kiln Firing					√*							30%			460	
Lime Kilns	Low NOx Burner					√*							30%			560	
Medical Waste Incinerators	Selective Non-Catalytic Reduction (SNCR)					√*			X				45%			4,510	
Municipal Waste Combustors	Selective Non-Catalytic Reduction (SNCR)					√*			X				45%			1,130	
Natural Gas Production; Compressors - Small Sources	Selective Catalytic Reduction (SCR)					√*			X				20%			1,651	
Nitric Acid Manufacturing - Small Sources	Extended Absorption					√*							95%			480	
Nitric Acid Manufacturing - Small Sources	Non-Selective Catalytic Reduction (NSCR)					√*			X				98%		510	550	710
Nitric Acid Manufacturing - Small Sources	Selective Catalytic Reduction (SCR)					√*			X				97%			590	
Off-Highway Diesel Vehicles	Final Compression-Ignition (C-I) Engine Standards	√	√			√*	√			√		65%	72%	79%		N/A	
Off-Highway Diesel Vehicles	Final Compression-Ignition (C-I) Engine Standards	√	√			√*	√			√		21%	30%	59%		N/A	

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Off-Highway Diesel Vehicles	Final Compression-Ignition (C-I) Engine Standards	√	√			√*	√			√		34%	45.5%	57%		N/A	
Off-Highway Diesel Vehicles	Final Compression-Ignition (C-I) Engine Standards	√	√			√*	√			√		49%	62%	75%		N/A	
Off-Highway Gasoline Vehicles	Large Spark-Ignition (S-I) Engine Standards	√	√			√*	√			√		-26%	35.5%	77%		N/A	
Off-Highway Gasoline Vehicles	Large Spark-Ignition (S-I) Engine Standards	√	√			√*	√			√		-26%	33.5%	93%		N/A	
Off-Highway Gasoline Vehicles	Large Spark-Ignition (S-I) Engine Standards	√	√			√*	√			√		-32%	33.5%	91%		N/A	
Off-Highway Gasoline Vehicles	Large Spark-Ignition (S-I) Engine Standards	√	√			√*	√			√		-31%	29%	95%		N/A	
Open Burning	Episodic Ban (Daily Only)					√*							100%			N/A	
Plastics Prod-Specific; (ABS) - Small Sources	Low NOx Burner + Flue Gas Recirculation					√*							55%		1,430	3,190	3,190
Process Heaters - Distillate Oil - Small Sources	Ultra Low NOx Burner					√*							74%			2,140	
Process Heaters - Distillate Oil - Small Sources	Low NOx Burner (LNB) + Selective Catalytic Reduction (SCR)					√*			X				92%		9,120	9,120	15,350
Process Heaters - Distillate Oil - Small Sources	Selective Catalytic Reduction (SCR)					√*			X				75%			9,230	

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Process Heaters - Distillate Oil - Small Sources	Selective Non-Catalytic Reduction (SNCR)					√*			X				60%			3,180	
Process Heaters - Distillate Oil - Small Sources	Low NOx Burner + Flue Gas Recirculation					√*							48%		4,250	4,250	19,540
Process Heaters - Distillate Oil - Small Sources	Low NOx Burner - Selective Non-Catalytic Reduction (SNCR)					√*			X				78%		3,620	3,620	3,830
Process Heaters - Distillate Oil - Small Sources	Low NOx Burner					√*							45%			3,470	
Process Heaters - LPG - Small Sources	Low NOx Burner (LNB) + SNCR					√*			X				78%		3,620	3,620	3,830
Process Heaters - LPG - Small Sources	Selective Non-Catalytic Reduction (SNCR)					√*			X				60%			3,180	
Process Heaters - LPG - Small Sources	Ultra Low NOx Burner					√*							74%			2,140	
Process Heaters - LPG - Small Sources	Low NOx Burner (LNB) + Selective Catalytic Reduction (SCR)					√*			X				92%		9,120	9,120	15,350
Process Heaters - LPG - Small Sources	Low NOx Burner + Flue Gas Recirculation					√*							48%		4,250	4,250	19,540
Process Heaters - LPG - Small Sources	Low NOx Burner					√*							45%			3,470	
Process Heaters - LPG - Small Sources	Selective Catalytic Reduction (SCR)					√*			X				75%			9,230	

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Process Heaters - Natural Gas - Small Sources	Ultra Low NOx Burner					√*							75%			1,500	
Process Heaters - Natural Gas - Small Sources	Low NOx Burner (LNB) + Selective Catalytic Reduction (SCR)					√*			X				88%		11,560	11,560	27,910
Process Heaters - Natural Gas - Small Sources	Selective Non-Catalytic Reduction (SNCR)					√*			X				60%			2,850	
Process Heaters - Natural Gas - Small Sources	Low NOx Burner + Flue Gas Recirculation					√*							55%		3,190	3,190	15,580
Process Heaters - Natural Gas - Small Sources	Low NOx Burner					√*							50%			2,200	
Process Heaters - Natural Gas - Small Sources	Selective Catalytic Reduction (SCR)					√*			X				75%			12,040	
Process Heaters - Natural Gas - Small Sources	Low NOx Burner (LNB) + SNCR					√*			X				80%		3,520	3,520	6,600
Process Heaters - Other Fuel - Small Sources	Low NOx Burner (LNB) + Selective Catalytic Reduction (SCR)					√*			X				91%		5,420	5,420	7,680
Process Heaters - Other Fuel - Small Sources	Selective Catalytic Reduction (SCR)					√*			X				75%			5,350	
Process Heaters - Other Fuel - Small Sources	Low NOx Burner (LNB) + SNCR					√*			X				75%		2,230	2,300	2,860
Process Heaters - Other Fuel - Small Sources	Ultra Low NOx Burner					√*							73%			1,290	

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Process Heaters - Other Fuel - Small Sources	Selective Non-Catalytic Reduction (SNCR)					√*			X				60%			1,930	
Process Heaters - Other Fuel - Small Sources	Low NOx Burner					√*							37%			2,520	
Process Heaters - Other Fuel - Small Sources	Low NOx Burner + Flue Gas Recirculation					√*							34%			3,490	
Process Heaters - Process Gas - Small Sources	Low NOx Burner					√*							50%			2,200	
Process Heaters - Process Gas - Small Sources	Low NOx Burner (LNB) + Selective Catalytic Reduction (SCR)					√*			X				88%		11,560	11,560	27,910
Process Heaters - Process Gas - Small Sources	Low NOx Burner (LNB) + Selective Reduction SNCR					√*			X				80%		3,520	3,520	6,600
Process Heaters - Process Gas - Small Sources	Selective Catalytic Reduction (SCR)					√*			X				75%			12,040	
Process Heaters - Process Gas - Small Sources	Ultra Low NOx Burner					√*							75%			1,500	
Process Heaters - Process Gas - Small Sources	Selective Non-Catalytic Reduction (SNCR)					√*			X				60%			2,850	
Process Heaters - Process Gas - Small Sources	Low NOx Burner + Flue Gas Recirculation					√*							55%		1,430	3,190	3,190
Process Heaters - Residual Oil - Small Sources	Ultra Low NOx Burner					√*							73%			1,290	

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Process Heaters - Residual Oil - Small Sources	Low NOx Burner + Flue Gas Recirculation					√*							34%			3,490	
Process Heaters - Residual Oil - Small Sources	Low NOx Burner					√*							37%			2,520	
Process Heaters - Residual Oil - Small Sources	Low NOx Burner (LNB) + SCR					√*			X				75%		2,230	2,300	2,860
Process Heaters - Residual Oil - Small Sources	Low NOx Burner (LNB) + Selective Catalytic Reduction (SCR)					√*			X				91%		5,420	5,420	7,680
Process Heaters - Residual Oil - Small Sources	Selective Non-Catalytic Reduction (SNCR)					√*			X				60%			1,930	
Process Heaters - Residual Oil - Small Sources	Selective Catalytic Reduction (SCR)					√*			X				75%			5,350	
Residential Natural Gas	Water Heater Replacement					√*							7%			N/A	
Residential Natural Gas	Water Heater + LNB Space Heaters					√*							7%			1,230	
Rich-Burn Stationary Reciprocating Internal Combustion Engines	Non-selective catalytic reduction					√*							90%			342	
Rich-Burn Stationary Reciprocating Internal Combustion Engines	Non-selective catalytic reduction					√*							90%			342	
Rich-Burn Stationary Reciprocating Internal Combustion Engines (RICE)	Non-selective catalytic reduction (NSCR)					√*	√			√			90%			342	

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Sand/Gravel; Dryer - Small Sources	Low NOx Burner + Flue Gas Recirculation					√*							55%		1,430	3,190	3,190
Secondary Aluminum Production; Smelting Furnaces	Low NOx Burner					√*							50%			570	
Solid Waste Disposal; Government; Other	Selective Non-Catalytic Reduction (SNCR)					√*			X				45%			1,130	
Space Heaters - Distillate Oil - Small Sources	Low NOx Burner + Flue Gas Recirculation					√*							60%		1,090	2,490	2,490
Space Heaters - Distillate Oil - Small Sources	Selective Catalytic Reduction (SCR)					√*			X				80%		2,780	2,780	3,570
Space Heaters - Distillate Oil - Small Sources	Selective Non-Catalytic Reduction (SNCR)					√*			X				50%		3,470	4,640	4,640
Space Heaters - Distillate Oil - Small Sources	Low NOx Burner					√*							50%			1,180	
Space Heaters - Natural Gas - Small Sources	Low NOx Burner					√*							50%			820	
Space Heaters - Natural Gas - Small Sources	Selective Non-Catalytic Reduction (SNCR)					√*			X				50%		2,900	3,870	3,870
Space Heaters - Natural Gas - Small Sources	Selective Catalytic Reduction (SCR)					√*			X				80%		2,230	2,230	2,860
Space Heaters - Natural Gas - Small Sources	Low NOx Burner + Flue Gas Recirculation					√*							60%		2,470	2,560	2,560

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		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Space Heaters - Natural Gas - Small Sources	Oxygen Trim + Water Injection					√*							65%			680	
Starch Manufacturing; Combined Operation - Small Sources	Low NOx Burner + Flue Gas Recirculation					√*							55%		1,430	3,190	3,190
Steel Foundries; Heat Treating	Low NOx Burner					√*							50%			570	
Steel Production; Soaking Pits	Low NOx Burner + Flue Gas Recirculation					√*							60%		250	750	750
Sulfate Pulping - Recovery Furnaces - Small Sources	Selective Non-Catalytic Reduction (SNCR)					√*			X				50%		2,900	3,870	3,870
Sulfate Pulping - Recovery Furnaces - Small Sources	Low NOx Burner					√*							50%			820	
Sulfate Pulping - Recovery Furnaces - Small Sources	Oxygen Trim + Water Injection					√*							65%			680	
Sulfate Pulping - Recovery Furnaces - Small Sources	Selective Catalytic Reduction (SCR)					√*			X				80%		2,230	2,230	2,860
Sulfate Pulping - Recovery Furnaces - Small Sources	Low NOx Burner + Flue Gas Recirculation					√*							60%		2,470	2,560	2,560
Surface Coat Oper; Coating Oven Htr; Nat Gas - Small Sources	Low NOx Burner					√*			X				50%			2,200	
Utility Boiler - Coal/Tangential	Low Nox Coal-and-Air Nozzles with separated Overfire Air (LNC2)					√*							48%			N/A	

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		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Utility Boiler - Coal/Tangential	Low Nox Coal-and-Air Nozzles with cross-Coupled Overfire Air (LNC1)					√*							33%			N/A	
Utility Boiler - Coal/Tangential	Low Nox Coal-and-Air Nozzles with separated Overfire Air (LNC2)					√*							38%			N/A	
Utility Boiler - Coal/Tangential	Low Nox Coal-and-Air Nozzles with Close-Coupled and Separated Overfire Air (LNC3)					√*							53%			N/A	
Utility Boiler - Coal/Tangential	Low Nox Coal-and-Air Nozzles with cross-Coupled Overfire Air (LNC1)					√*							43%			N/A	
Utility Boiler - Coal/Tangential	Low Nox Coal-and-Air Nozzles with Close-Coupled and Separated Overfire Air (LNC3)					√*							58%			N/A	
Utility Boiler - Coal/Tangential	Selective Non-Catalytic Reduction (SNCR)					√*			X				35%			N/A	
Utility Boiler - Coal/Tangential	Selective Catalytic Reduction (SCR)					√*			X		√		90% (Hg 95%)			N/A	
Utility Boiler - Coal/Tangential	Natural Gas Reburn (NGR)					√*							50%			N/A	
Utility Boiler - Coal/Wall	Low Nox Burner without Overfire Air					√*							41			N/A	
Utility Boiler - Coal/Wall	Low Nox Burner with Overfire Air					√*							56%			N/A	
Utility Boiler - Coal/Wall	Low Nox Burner with Overfire Air					√*							55%			N/A	

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		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Utility Boiler - Coal/Wall	Low Nox Burner without Overfire Air					√*							40%			N/A	
Utility Boiler - Coal/Wall	Selective Catalytic Reduction (SCR)					√*			X				90%			N/A	
Utility Boiler - Coal/Wall	Selective Non-Catalytic Reduction (SNCR)					√*			X				35%			N/A	
Utility Boiler - Coal/Wall	Natural Gas Reburn (NGR)					√*							50%			N/A	
Utility Boiler - Cyclone	Selective Non-Catalytic Reduction (SNCR)					√*			X				35%			N/A	
Utility Boiler - Cyclone	Natural Gas Reburn (NGR)					√*							50%			N/A	
Utility Boiler - Cyclone	Selective Catalytic Reduction (SCR)					√*			X				80%			N/A	
Utility Boiler - Oil-Gas/Tangential	Natural Gas Reburn (NGR)					√*							50%			N/A	
Utility Boiler - Oil-Gas/Tangential	Selective Catalytic Reduction (SCR)					√*			X				80%			N/A	
Utility Boiler - Oil-Gas/Tangential	Selective Non-Catalytic Reduction (SNCR)					√*			X				50%			N/A	
Utility Boiler - Oil-Gas/Wall	Selective Non-Catalytic Reduction (SNCR)					√*			X				50%			N/A	

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		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Utility Boiler - Oil-Gas/Wall	Natural Gas Reburn (NGR)					√*							50%			N/A	
Utility Boiler - Oil-Gas/Wall	Selective Catalytic Reduction (SCR)					√*			X				80%			N/A	
Agricultural Burning	Bale Stack/Propane Burning	√	√*	√	√							49%	63%	63%		2,591	
Agricultural Tilling	Soil Conservation Plans	√	√	√	√								11.7%			138	
Asphalt Manufacture	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	
Asphalt Manufacture	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	
Asphalt Manufacture	Paper/Nonwoven Filters - Cartridge Collector Type	√	√*	√	√								99%		85	147	256
Asphalt Manufacture	Fabric Filter (Mech. Shaker Type)	√	√*	√	√								99%		37	126	303
Asphalt Manufacture	Fabric Filter (Pulse Jet Type)	√	√*	√	√								99%		42	117	266
Asphalt Manufacture	Fabric Filter (Reverse-Air Cleaned Type)	√	√*	√	√								99%		53	148	337
Beef Cattle Feedlots	Watering	√	√*	√	√								50%			307	

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Chemical Manufacture	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	
Chemical Manufacture	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	
Chemical Manufacture	Wet ESP - Wire Plate Type	√	√*	√	√								99%		55	220	550
Commercial Institutional Boilers - Coal	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	
Commercial Institutional Boilers - Coal	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	
Commercial Institutional Boilers - Coal	Dry ESP-Wire Plate Type	√	√*	√	√								98%		40	110	250
Commercial Institutional Boilers - Coal	Fabric Filter (Reverse-Air Cleaned Type)	√	√*	√	√								99%		53	148	337
Commercial Institutional Boilers - Coal	Fabric Filter (Pulse Jet Type)	√	√*	√	√								99%		42	117	266
Commercial Institutional Boilers - Liquid Waste	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	
Commercial Institutional Boilers - Liquid Waste	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	
Commercial Institutional Boilers - LPG	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Commercial Institutional Boilers - LPG	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	
Commercial Institutional Boilers - Natural Gas	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	
Commercial Institutional Boilers - Natural Gas	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	
Commercial Institutional Boilers - Oil	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	
Commercial Institutional Boilers - Oil	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	
Commercial Institutional Boilers - Oil	Dry ESP-Wire Plate Type	√	√*	√	√								98%		40	110	250
Commercial Institutional Boilers - Process Gas	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	
Commercial Institutional Boilers - Process Gas	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	
Commercial Institutional Boilers - Solid Waste	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	
Commercial Institutional Boilers - Solid Waste	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	
Commercial Institutional Boilers - Wood	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Commercial Institutional Boilers - Wood	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	
Commercial Institutional Boilers - Wood/Bark	Fabric Filter (Pulse Jet Type)	√	√*	√	√								99%		42	117	266
Commercial Institutional Boilers - Wood/Bark	Fabric Filter (Reverse-Air Cleaned Type)	√	√*	√	√								99%		53	148	337
Commercial Institutional Boilers - Wood/Bark	Dry ESP-Wire Plate Type	√	√*	√	√								98%		40	110	250
Construction Activities	Dust Control Plan	√	√*	√	√								62.5%			3,600	
Conveyorized Charbroilers	Catalytic Oxidizer	√*	√*				√					80%	83%	90%		2,966	
Electric Generation - Coke	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	
Electric Generation - Coke	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	
Electric Generation - Bagasse	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	
Electric Generation - Bagasse	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	
Electric Generation - Coal	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Electric Generation - Coal	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	
Electric Generation - Liquid Waste	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	
Electric Generation - Liquid Waste	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	
Electric Generation - LPG	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	
Electric Generation - LPG	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	
Electric Generation - Natural Gas	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	
Electric Generation - Natural Gas	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	
Electric Generation - Oil	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	
Electric Generation - Oil	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	
Electric Generation - Solid Waste	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	
Electric Generation - Solid Waste	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Electric Generation - Wood	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	
Electric Generation - Wood	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	
Fabricated Metal Products - Abrasive Blasting	Paper/Nonwoven Filters - Cartridge Collector Type	√	√*	√	√								99%		85	142	256
Fabricated Metal Products - Welding	Paper/Nonwoven Filters - Cartridge Collector Type	√	√*	√	√								99%		85	142	256
Ferrous Metals Processing - Coke	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	
Ferrous Metals Processing - Coke	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	
Ferrous Metals Processing - Coke	Fabric Filter (Mech. Shaker Type)	√	√*	√	√								99%		37	126	303
Ferrous Metals Processing - Coke	Fabric Filter (Reverse-Air Cleaned Type)	√	√*	√	√								99%		53	148	337
Ferrous Metals Processing - Coke	Venturi Scrubber	√	√*	√	√								93%		75	751	2,100
Ferrous Metals Processing - Ferroalloy Production	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	
Ferrous Metals Processing - Ferroalloy Production	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Ferrous Metals Processing - Ferroalloy Production	Fabric Filter (Reverse-Air Cleaned Type)	√	√*	√	√								99%		53	148	337
Ferrous Metals Processing - Ferroalloy Production	Dry ESP-Wire Plate Type	√	√*	√	√								98%		40	110	250
Ferrous Metals Processing - Ferroalloy Production	Fabric Filter (Mech. Shaker Type)	√	√*	√	√								99%		37	126	303
Ferrous Metals Processing - Gray Iron Foundries	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	
Ferrous Metals Processing - Gray Iron Foundries	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	
Ferrous Metals Processing - Gray Iron Foundries	Impingement-Plate Scrubber	√	√*	√	√								64%		46	431	1,200
Ferrous Metals Processing - Gray Iron Foundries	Venturi Scrubber	√	√*	√	√								94%		76	751	2,100
Ferrous Metals Processing - Gray Iron Foundries	Fabric Filter (Mech. Shaker Type)	√	√*	√	√								99%		37	126	303
Ferrous Metals Processing - Gray Iron Foundries	Fabric Filter (Reverse-Air Cleaned Type)	√	√*	√	√								99%		53	148	337
Ferrous Metals Processing - Gray Iron Foundries	Dry ESP-Wire Plate Type	√	√*	√	√								98%		40	110	250
Ferrous Metals Processing - Iron & Steel Production	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Ferrous Metals Processing - Iron & Steel Production	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	
Ferrous Metals Processing - Iron and Steel Production	Venturi Scrubber	√	√*	√	√								73%		76	751	2,100
Ferrous Metals Processing - Iron and Steel Production	Fabric Filter (Pulse Jet Type)	√	√*	√	√								99%		42	117	266
Ferrous Metals Processing - Iron and Steel Production	Fabric Filter (Mech. Shaker Type)	√	√*	√	√								99%		37	126	303
Ferrous Metals Processing - Iron and Steel Production	Dry ESP-Wire Plate Type	√	√*	√	√								98%		40	110	250
Ferrous Metals Processing - Iron and Steel Production	Wet ESP - Wire Plate Type	√	√*	√	√								99%		55	220	550
Ferrous Metals Processing - Iron and Steel Production	Fabric Filter (Reverse-Air Cleaned Type)	√	√*	√	√								99%		53	148	337
Ferrous Metals Processing - Other	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	
Ferrous Metals Processing - Other	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	
Ferrous Metals Processing - Steel Foundries	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	
Ferrous Metals Processing - Steel Foundries	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Ferrous Metals Processing - Steel Foundries	Venturi Scrubber	√	√*	√	√								73%		76	751	2,100
Ferrous Metals Processing - Steel Foundries	Fabric Filter (Mech. Shaker Type)	√	√*	√	√								99%		37	126	303
Ferrous Metals Processing - Steel Foundries	Wet ESP - Wire Plate Type	√	√*	√	√								99%		55	220	550
Ferrous Metals Processing - Steel Foundries	Dry ESP-Wire Plate Type	√	√*	√	√								98%		40	110	250
Ferrous Metals Processing - Steel Foundries	Fabric Filter (Reverse-Air Cleaned Type)	√	√*	√	√								99%		53	148	337
Ferrous Metals Processing - Steel Foundries	Fabric Filter (Pulse Jet Type)	√	√*	√	√								99%		42	117	266
Grain Milling	Fabric Filter (Reverse-Air Cleaned Type)	√	√*	√	√								99%		53	148	337
Grain Milling	Fabric Filter (Pulse Jet Type)	√	√*	√	√								99%		42	117	266
Grain Milling	Paper/Nonwoven Filters - Cartridge Collector Type	√	√*	√	√								99%		85	142	256
Highway Vehicles - Gasoline Engine	RFG and High Enhanced I/M Program					√	√*			√		-9.1%	11.4%	31.9%	484	16,164	
Highway Vehicles - Heavy Duty Diesel Engines	Voluntary Diesel Retrofit Program: Diesel Particulate Filter	√	√*				√	√		√			61.99%			727,689	

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Highway Vehicles - Heavy Duty Diesel Engines	Voluntary Diesel Retrofit Program: Biodiesel Fuel	√	√*				√			√			7%			209,913	
Highway Vehicles - Heavy Duty Diesel Engines	Voluntary Diesel Retrofit Program: Diesel Oxidation Catalyst	√	√*				√	√		√			24.01%			167,640	
Industrial Boilers - Coal	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	
Industrial Boilers - Coal	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	
Industrial Boilers - Coal	Fabric Filter (Pulse Jet Type)	√	√*	√	√								99%		42	117	266
Industrial Boilers - Coal	Fabric Filter (Reverse-Air Cleaned Type)	√	√*	√	√								99%		53	148	337
Industrial Boilers - Coal	Venturi Scrubber	√	√*	√	√								82%		76	751	2,100
Industrial Boilers - Coal	Dry ESP-Wire Plate Type	√	√*	√	√								98%		40	110	250
Industrial Boilers - Coke	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	
Industrial Boilers - Coke	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	
Industrial Boilers - Liquid Waste	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Industrial Boilers - Liquid Waste	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	
Industrial Boilers - Liquid Waste	Dry ESP-Wire Plate Type	√	√*	√	√								98%		40	110	250
Industrial Boilers - LPG	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	
Industrial Boilers - LPG	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	
Industrial Boilers - Natural Gas	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	
Industrial Boilers - Natural Gas	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	
Industrial Boilers - Oil	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	
Industrial Boilers - Oil	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	
Industrial Boilers - Oil	Venturi Scrubber	√	√*	√	√								92%		76	751	2,100
Industrial Boilers - Oil	Dry ESP-Wire Plate Type	√	√*	√	√								98%		40	110	250
Industrial Boilers - Process Gas	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Industrial Boilers - Process Gas	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	
Industrial Boilers - Solid Waste	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	
Industrial Boilers - Solid Waste	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	
Industrial Boilers - Wood	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	
Industrial Boilers - Wood	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	
Industrial Boilers - Wood	Venturi Scrubber	√	√*	√	√								93%		76	751	2,100
Industrial Boilers - Wood	Dry ESP-Wire Plate Type	√	√*	√	√								98%		40	110	250
Industrial Boilers - Wood	Fabric Filter (Reverse-Air Cleaned Type)	√	√*	√	√								99%		53	148	337
Industrial Boilers - Wood	Fabric Filter (Pulse Jet Type)	√	√*	√	√								99%		42	117	266
Mineral Products - Cement Manufacture	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	
Mineral Products - Cement Manufacture	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Mineral Products - Cement Manufacture	Fabric Filter (Mech. Shaker Type)	√	√*	√	√								99%		37	126	303
Mineral Products - Cement Manufacture	Fabric Filter (Reverse-Air Cleaned Type)	√	√*	√	√								99%		53	148	337
Mineral Products - Cement Manufacture	Paper/Nonwoven Filters - Cartridge Collector Type	√	√*	√	√								99%		85	142	256
Mineral Products - Cement Manufacture	Dry ESP-Wire Plate Type	√	√*	√	√								98%		40	110	250
Mineral Products - Cement Manufacture	Fabric Filter (Pulse Jet Type)	√	√*	√	√								99%		42	117	266
Mineral Products - Coal Cleaning	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	
Mineral Products - Coal Cleaning	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	
Mineral Products - Coal Cleaning	Venturi Scrubber	√	√*	√	√								99%		76	751	2,100
Mineral Products - Coal Cleaning	Fabric Filter (Mech. Shaker Type)	√	√*	√	√								99%		37	126	303
Mineral Products - Coal Cleaning	Fabric Filter (Pulse Jet Type)	√	√*	√	√								99%		42	117	266
Mineral Products - Coal Cleaning	Paper/Nonwoven Filters - Cartridge Collector Type	√	√*	√	√								99%		85	142	256

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Mineral Products - Coal Cleaning	Fabric Filter (Reverse-Air Cleaned Type)	√	√*	√	√								99%		53	148	337
Mineral Products - Other	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	
Mineral Products - Other	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	
Mineral Products - Other	Paper/Nonwoven Filters - Cartridge Collector Type	√	√*	√	√								99%		85	145	256
Mineral Products - Other	Wet ESP - Wire Plate Type	√	√*	√	√								99%		55	220	550
Mineral Products - Other	Dry ESP-Wire Plate Type	√	√*	√	√								98%		40	110	250
Mineral Products - Other	Fabric Filter (Pulse Jet Type)	√	√*	√	√								99%		42	117	266
Mineral Products - Other	Fabric Filter (Reverse-Air Cleaned Type)	√	√*	√	√								99%		53	148	337
Mineral Products - Other	Fabric Filter (Mech. Shaker Type)	√	√*	√	√								99%		37	126	303
Mineral Products - Stone Quarrying & Processing	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	
Mineral Products - Stone Quarrying & Processing	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Mineral Products - Stone Quarrying and Processing	Fabric Filter (Pulse Jet Type)	√	√*	√	√								99%		42	117	266
Mineral Products - Stone Quarrying and Processing	Dry ESP-Wire Plate Type	√	√*	√	√								98%		40	110	250
Mineral Products - Stone Quarrying and Processing	Venturi Scrubber	√	√*	√	√								95%		76	751	2,100
Mineral Products - Stone Quarrying and Processing	Fabric Filter (Reverse-Air Cleaned Type)	√	√*	√	√								99%		53	148	337
Mineral Products - Stone Quarrying and Processing	Paper/Nonwoven Filters - Cartridge Collector Type	√	√*	√	√								99%		85	142	256
Mineral Products - Stone Quarrying and Processing	Wet ESP - Wire Plate Type	√	√*	√	√								99%		55	220	550
Mineral Products - Stone Quarrying and Processing	Fabric Filter (Mech. Shaker Type)	√	√*	√	√								99%		37	126	303
Municipal Waste Incineration	Dry ESP-Wire Plate Type	√	√*	√									98%		40	110	250
Non-Ferrous Metals Processing - Aluminum	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	
Non-Ferrous Metals Processing - Aluminum	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	
Non-Ferrous Metals Processing - Aluminum	Fabric Filter (Mech. Shaker Type)	√	√*	√	√								99%		37	126	303

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Non-Ferrous Metals Processing - Aluminum	Fabric Filter (Reverse-Air Cleaned Type)	√	√*	√	√								99%		53	148	337
Non-Ferrous Metals Processing - Aluminum	Wet ESP - Wire Plate Type	√	√*	√	√								99%		55	220	550
Non-Ferrous Metals Processing - Aluminum	Dry ESP-Wire Plate Type	√	√*	√	√								98%		40	110	250
Non-Ferrous Metals Processing - Copper	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	
Non-Ferrous Metals Processing - Copper	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	
Non-Ferrous Metals Processing - Copper	Fabric Filter (Mech. Shaker Type)	√	√*	√	√								99%		37	126	303
Non-Ferrous Metals Processing - Copper	Fabric Filter (Reverse-Air Cleaned Type)	√	√*	√	√								99%		53	148	337
Non-Ferrous Metals Processing - Copper	Dry ESP-Wire Plate Type	√	√*	√	√								98%		40	110	250
Non-Ferrous Metals Processing - Copper	Wet ESP - Wire Plate Type	√	√*	√	√								99%		55	220	550
Non-Ferrous Metals Processing - Lead	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	
Non-Ferrous Metals Processing - Lead	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Non-Ferrous Metals Processing - Lead	Fabric Filter (Reverse-Air Cleaned Type)	√	√*	√	√								99%		53	148	337
Non-Ferrous Metals Processing - Lead	Wet ESP - Wire Plate Type	√	√*	√	√								99%		55	220	550
Non-Ferrous Metals Processing - Lead	Dry ESP-Wire Plate Type	√	√*	√	√								98%		40	110	250
Non-Ferrous Metals Processing - Lead	Fabric Filter (Mech. Shaker Type)	√	√*	√	√								99%		37	126	303
Non-Ferrous Metals Processing - Other	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	
Non-Ferrous Metals Processing - Other	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	
Non-Ferrous Metals Processing - Other	Fabric Filter (Reverse-Air Cleaned Type)	√	√*	√	√								99%		53	148	337
Non-Ferrous Metals Processing - Other	Wet ESP - Wire Plate Type	√	√*	√	√								99%		55	220	550
Non-Ferrous Metals Processing - Other	Dry ESP-Wire Plate Type	√	√*	√	√								98%		40	110	250
Non-Ferrous Metals Processing - Other	Fabric Filter (Mech. Shaker Type)	√	√*	√	√								99%		37	1,260	303
Non-Ferrous Metals Processing - Zinc	Increased Monitoring Frequency (IMF) of PM Controls	√*	√*										6.5%			620	

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Non-Ferrous Metals Processing - Zinc	CEM Upgrade and Increased Monitoring Frequency of PM Controls	√*	√*										7.7%			5,200	
Non-Ferrous Metals Processing - Zinc	Fabric Filter (Mech. Shaker Type)	√	√*	√	√								99%		37	126	303
Non-Ferrous Metals Processing - Zinc	Dry ESP-Wire Plate Type	√	√*	√	√								98%		40	110	250
Non-Ferrous Metals Processing - Zinc	Wet ESP - Wire Plate Type	√	√*	√	√								99%		55	220	550
Non-Ferrous Metals Processing - Zinc	Fabric Filter (Reverse-Air Cleaned Type)	√	√*	√	√								99%		53	148	337
Nonroad Diesel Engines	Heavy Duty Retrofit Program	√	√*	√	√								1%			9,500	
Paved Roads	Vacuum Sweeping	√	√*	√	√								50.5%			485	
Prescribed Burning	Increase Fuel Moisture	√	√*	√	√								50%			2,617	
Residential Wood Combustion	Education and Advisory Program	√	√*	√	√								50%			1,320	
Residential Wood Stoves	NSPS compliant Wood Stoves	√*	√*										98%			2,000	
Unpaved Roads	Chemical Stabilization	√	√*	√									37.5%			2,753	

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		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Unpaved Roads	Hot Asphalt Paving	√	√*	√	√								67.5%			537	
Utility Boilers - Coal	Fabric Filter (Mech. Shaker Type)	√	√*	√	√						√		99.5%		37	126	303
Utility Boilers - Coal	Dry ESP-Wire Plate Type	√	√*	√	√						√	(Hg 3%)	98% (Hg 20%)	(Hg 36%)	40	110	250
Utility Boilers - Coal	Fabric Filter	√	√*	√	√						√		95% (Hg 80%)			N/A	
Utility Boilers - Coal	Fabric Filter (Pulse Jet Type)	√	√*	√	√						√		99%		42	117	266
Utility Boilers - Coal	Fabric Filter (Reverse-Air Cleaned Type)	√	√*	√	√						√		99%		53	148	337
Utility Boilers - Gas/Oil	Fabric Filter	√	√*	√	√						√		95%			N/A	
Wood Pulp & Paper	Wet ESP - Wire Plate Type	√	√*	√	√								99%		55	220	550
Wood Pulp & Paper	Dry ESP-Wire Plate Type	√	√*	√	√								98%		40	110	250
Bituminous/Subbituminous Coal	Flue Gas Desulfurization							√*					90%			N/A	
Bituminous/Subbituminous Coal	Flue Gas Desulfurization							√*					90%			N/A	

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		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Bituminous/Subbituminous Coal (Industrial Boilers)	Wet Flue Gas Desulfurization							√*					90%		1,027	1,536	1,980
Bituminous/Subbituminous Coal (Industrial Boilers)	Spray Dryer Absorber							√*					90%		804	1,341	1,973
Bituminous/Subbituminous Coal (Industrial Boilers)	In-duct Dry Sorbent Injection							√*					40%		1,111	1,526	2,107
By-Product Coke Manufacturing	Vacuum Carbonate Plus Sulfur Recovery Plant							√*					82%			N/A	
Distillate Oil (Industrial Boiler)	Wet Flue Gas Desulfurization							√*					90%		2,295	3,489	4,524
Inorganic Chemical Manufacture	Flue Gas Desulfurization							√*					90%			N/A	
In-process Fuel Use - Bituminous Coal	Flue Gas Desulfurization							√*					90%			N/A	
Lignite (Industrial Boiler)	Wet Flue Gas Desulfurization							√*					90%		1,027	1,536	1,980
Lignite (Industrial Boiler)	Spray Dryer Absorber							√*					90%		804	1,341	1,973
Lignite (Industrial Boiler)	In-duct Dry Sorbent Injection							√*					40%		1,111	1,526	2,107
Lignite (Industrial Boilers)	Flue Gas Desulfurization							√*					90%			N/A	

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Mineral Products Industry	Flue Gas Desulfurization							√*					90%			N/A	
Petroleum Industry	Flue Gas Desulfurization (FGD)							√*					90%			N/A	
Primary Lead Smelters - Sintering	Dual Absorption							√*					99%			N/A	
Primary Metals Industry	Flue Gas Desulfurization							√*					90%			N/A	
Primary Zinc Smelters - Sintering	Dual Absorption							√*					99%			N/A	
Process Heaters (Oil and Gas Production)	Flue Gas Desulfurization							√*					90%			N/A	
Pulp and Paper Industry (Sulfate Pulping)	Flue Gas Desulfurization							√*					90%			N/A	
Residual Oil (Commercial/Institutional Boilers)	Wet Flue Gas Desulfurization							√*					90%		2,295	3,489	4,524
Residual Oil (Commercial/Institutional Boilers)	Flue Gas Desulfurization							√*					90%			N/A	
Residual Oil (Industrial Boilers)	Flue Gas Desulfurization							√*					90%			N/A	
Secondary Metal Production	Flue Gas Desulfurization							√*					90%			N/A	

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		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Steam Generating Unit-Coal/Oil	Flue Gas Desulfurization							√*					90%			N/A	
Sulfur Recovery Plants - Elemental Sulfur	Amine Scrubbing + Flue Gas Desulfurization							√*					99.7%			N/A	
Sulfur Recovery Plants - Elemental Sulfur	Amine Scrubbing							√*					97.8%			N/A	
Sulfur Recovery Plants - Elemental Sulfur	Amine Scrubbing + Flue Gas Desulfurization							√*					99.8%			N/A	
Sulfur Recovery Plants - Elemental Sulfur	Amine Scrubbing + Flue Gas Desulfurization							√*					99.8%			N/A	
Sulfur Recovery Plants - Elemental Sulfur	Amine Scrubbing							√*					97.1%			N/A	
Sulfur Recovery Plants - Elemental Sulfur	Amine Scrubbing							√*					98.4%			N/A	
Sulfur Recovery Plants - Elemental Sulfur	Flue Gas Desulfurization							√*					90%			N/A	
Sulfur Recovery Plants - Sulfur Removal	Flue Gas Desulfurization							√*					90%			N/A	
Sulfuric Acid Plants - Contact Absorbers	Increase Absorption Efficiency from Existing to NSPS Level (99.7%) + Flue Gas Desulfurization							√*					85%			N/A	
Sulfuric Acid Plants - Contact Absorbers	Increase Absorption Efficiency from Existing to NSPS Level (99.7%)							√*					75%			N/A	

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		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Sulfuric Acid Plants - Contact Absorbers	Increase Absorption Efficiency from Existing to NSPS Level (99.7%) + Flue Gas Desulfurization							√*					75%			N/A	
Sulfuric Acid Plants - Contact Absorbers	Increase Absorption Efficiency from Existing to NSPS Level (99.7%)							√*					95%			N/A	
Sulfuric Acid Plants - Contact Absorbers	Increase Absorption Efficiency from Existing to NSPS Level (99.7%)							√*					85%			N/A	
Sulfuric Acid Plants - Contact Absorbers	Increase Absorption Efficiency from Existing to NSPS Level (99.7%) + Flue Gas Desulfurization							√*					95%			N/A	
Sulfuric Acid Plants - Contact Absorbers	Flue Gas Desulfurization							√*					90%			N/A	
Sulfuric Acid Plants - Contact Absorbers	Increase Absorption Efficiency from Existing to NSPS Level (99.7%)							√*					90%			N/A	
Sulfuric Acid Plants - Contact Absorbers	Increase Absorption Efficiency from Existing to NSPS Level (99.7%) + Flue Gas Desulfurization							√*					90%			N/A	
Utility Boilers - Coal-Fired	Fuel Switching - High-Sulfur Coal to Low-Sulfur Coal	√	√					√*					60%		113	140	167
Utility Boilers - Coal-Fired	Coal Washing	√	√					√*			√		40%		70	320	563
Utility Boilers - Coal-Fired	Repowering to IGCC					√		√*			√		99%			N/A	
Utility Boilers - High Sulfur Content	Flue Gas Desulfurization (Wet Scrubber Type)							√*			√	(Hg 29%)	90% (Hg 64%)	(Hg 98%)		N/A	

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		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Utility Boilers - Medium Sulfur Content	Flue Gas Desulfurization (Wet Scrubber Type)							√*			√	(Hg 29%)	90% (Hg 64%)	(Hg 98%)		N/A	
Utility Boilers - Very High Sulfur Content	Flue Gas Desulfurization (Wet Scrubber Type)							√*			√		90%			N/A	
Adhesives - Industrial	SCAQMD Rule 1168						√*						73%			2,202	
Aircraft Surface Coating	MACT Standard						√*						60%			165	
Architectural Coatings	OTC AIM Coating Rule						√*						55%			6,628	
Architectural Coatings	South Coast Phase I						√*						34%		3,300	1,443	4,600
Architectural Coatings	South Coast Phase III						√*						73%			10,059	
Architectural Coatings	AIM Coating Federal Rule						√*						20%			228	
Architectural Coatings	South Coast Phase II						√*						47%			4,017	
AREA	OTC Mobile Equipment Repair and Refinishing Rule						√*						61%			2,534	
AREA	OTC Solvent Cleaning Rule						√*						66%			1,400	

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
AREA	OTC Consumer Products Rule						√*						39.2%			1,032	
AREA	OTC Mobile Equipment Repair and Refinishing Rule						√*						61%			2,534	
AREA	OTC Mobile Equipment Repair and Refinishing Rule						√*						61%			2,534	
AREA	OTC Consumer Products Rule						√*						39.2%			1,032	
AREA	OTC Mobile Equipment Repair and Refinishing Rule						√*						61%			2,534	
Automobile Refinishing	Federal Rule						√*						37%			118	
Automobile Refinishing	California FIP Rule (VOC content & TE)						√*						89%			7,200	
Automobile Refinishing	CARB BARCT Limits						√*						47%			750	
Bakery Products	Incineration >100,000 lbs bread						√*						39.9%			1,470	
Commercial Adhesives	CARB Long-Term Limits						√*						85%			2,880	
Commercial Adhesives	CARB Mid-Term Limits						√*						55%			2,192	

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		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Commercial Adhesives	Federal Consumer Solvents Rule						√*						25%			232	
Consumer Solvents	CARB Long-Term Limits						√*						85%			2,880	
Consumer Solvents	CARB Mid-Term Limits						√*						55%			2,192	
Consumer Solvents	Federal Consumer Solvents Rule						√*						25%			232	
Cutback Asphalt	Switch to Emulsified Asphalts						√*						100%			15	
Electrical/Electronic Coating	SCAQMD Rule						√*						70%			5,976	
Electrical/Electronic Coating	MACT Standard						√*						36%			5,000	
Fabric Printing, Coating and Dyeing	Permanent Total Enclosure (PTE)						√*									N/A	
Flexographic Printing	Permanent Total Enclosure (PTE)						√*						95			9,947	
Graphic Arts	Use of Low or No VOC Materials						√*						65%		3,500	4,150	4,800
Highway Vehicles - Gasoline Engine	Federal Reformulated Gasoline (RFG)					X	√*			√		0%	7.65%	15.3%	2,498	25,093	

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Highway Vehicles - Light Duty Gasoline Engines	Basic Inspection and Maintenance Program	√	√			√	√*	√	√	√						N/A	
Industrial Maintenance Coating	South Coast Phase III						√*						73%			10,059	
Industrial Maintenance Coating	AIM Coating Federal Rule						√*						20%			228	
Industrial Maintenance Coating	South Coast Phase II						√*						47%			4,017	
Industrial Maintenance Coating	South Coast Phase I						√*						34%		3,300	1,443	4,600
Machinery, Equipment, and Railroad Coating	SCAQMD Limits						√*						55.2%			2,027	
Marine Surface Coating (Shipbuilding)	Add-On Controls						√*						90%			8,937	
Marine Surface Coating (Shipbuilding)	MACT Standard						√*						24%			2,090	
Metal Can Surface Coating Operations	Permanent Total Enclosure (PTE)						√*						95			8,469	
Metal Coil & Can Coating	Incineration						√*						90%			8,937	
Metal Coil & Can Coating	BAAQMD Rule 11 Amended						√*						42%			2,007	

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		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Metal Coil & Can Coating	MACT Standard						√*						36%			1,000	
Metal Furniture Surface Coating Operations	Permanent Total Enclosure (PTE)						√*						95			19,321	
Metal Furniture, Appliances, Parts	MACT Standard						√*						36%			1,000	
Metal Furniture, Appliances, Parts	SCAQMD Limits						√*						55.2%			2,027	
Miscellaneous Metal Products Coatings	MACT Standard						√*						36%			1,000	
Motor Vehicle Coating	Incineration						√*						90%			8,937	
Motor Vehicle Coating	MACT Standard						√*						36%			118	
Municipal Solid Waste Landfill	Gas Collection (SCAQMD/BAAQMD)						√*						70%			700	
Nonroad Gasoline Engines	Federal Reformulated Gasoline						√*						1.4%		440	4,854	9,250
Off-Highway Vehicles: All Terrain Vehicles (ATVs)	Recreational Gasoline ATV Standards	√	√			√	√*			√		27%	40%	73%		N/A	
Off-Highway Vehicles: All Terrain Vehicles (ATVs)	Recreational Gasoline ATV Standards	√	√			√	√*			√		33%	64%	95%		N/A	

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		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Off-Highway Vehicles: All Terrain Vehicles (ATVs)	Recreational Gasoline ATV Standards	√	√			√	√*			√		14%	24%	34%		N/A	
Off-Highway Vehicles: All Terrain Vehicles (ATVs)	Recreational Gasoline ATV Standards	√	√			√	√*			√		33%	65%	97%		N/A	
Off-Highway Vehicles: Motorcycles	Recreational Gasoline Off-Highway Motorcycle Standards	√	√			√	√*			√		10%	25%	40%		N/A	
Off-Highway Vehicles: Motorcycles	Recreational Gasoline Off-Highway Motorcycle Standards	√	√			√	√*			√		5%	12.5%	20%		N/A	
Off-Highway Vehicles: Motorcycles	Recreational Gasoline Off-Highway Motorcycle Standards	√	√			√	√*			√		12%	31%	50%		N/A	
Off-Highway Vehicles: Motorcycles	Recreational Gasoline Off-Highway Motorcycle Standards	√	√			√	√*			√		12%	32%	52%		N/A	
Off-Highway Vehicles: Snowmobiles	Recreational Gasoline Snowmobile Standards	√	√			X	√*			√			45%			N/A	
Off-Highway Vehicles: Snowmobiles	Recreational Gasoline Snowmobile Standards	√	√			X	√*			√			69%			N/A	
Off-Highway Vehicles: Snowmobiles	Recreational Gasoline Snowmobile Standards	√	√			X	√*			√			62%			N/A	
Off-Highway Vehicles: Snowmobiles	Recreational Gasoline Snowmobile Standards	√	√			X	√*			√			20%			N/A	
Oil and Natural Gas Production	Equipment and Maintenance						√*						37%			317	

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Open Top Degreasing	Title III MACT Standard						√*						31%			-69	
Open Top Degreasing	SCAQMD 1122 (VOC content limit)						√*						76%			1,248	
Open Top Degreasing	Airtight Degreasing System						√*						98%			9,789	
Paper and other Web Coating Operations	Permanent Total Enclosure (PTE)						√*						95			1,503	
Paper Surface Coating	Incineration						√*						78%			4,776	
Pesticide Application	Reformulation - FIP Rule						√*						20%			9,300	
Portable Gasoline Containers	OTC Portable Gas Container Rule						√*						33%			581	
Product and Packaging Rotogravure and Screen Printing	Permanent Total Enclosure (PTE)						√*						95			12,770	
Publication Rotogravure Printing	Permanent Total Enclosure (PTE)						√*						95			2,422	
Rubber and Plastics Manufacturing	SCAQMD - Low VOC						√*						60%			1,020	
Stage II Service Stations	Low Pressure/Vacuum Relief Valve						√*						91.6%		930	1,080	1,230

Source Category	Control Measure Name	Pollutant(s) Affected										Control Efficiency (% from baseline)			Average Annual Cost Effectiveness (\$/ton primary pollutant)		
		√ = pollutant reduction, X = pollutant increase, * = major pollutant										Low	Typical	High	Low	Typical	High
		PM2.5	PM10	EC	OC	NOx	VOC	SO2	NH3	CO	Hg						
Stage II Service Stations - Underground Tanks	Low Pressure/Vacuum Relief Valve						√*						73%		930	1,080	1,230
Traffic Markings	South Coast Phase III						√*						73%			1,059	
Traffic Markings	AIM Coating Federal Rule						√*						20%			228	
Traffic Markings	South Coast Phase I						√*						34%		8,600	1,443	12,800
Traffic Markings	South Coast Phase II						√*						47%			4,017	
Wood Furniture Surface Coating	Add-On Controls						√*					67%	75%	98%	468	20,000	22,100
Wood Furniture Surface Coating	New CTG						√*						47%		462	967	22,100
Wood Furniture Surface Coating	MACT Standard						√*						30%			446	
Wood Product Surface Coating	Incineration						√*						86%			4,202	
Wood Product Surface Coating	SCAQMD Rule 1104						√*						53%			881	
Wood Product Surface Coating	MACT Standard						√*						30%			446	

APPENDIX C: SCC / SIC / NAICS CROSSWALK

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Appendix C SCC-SIC-NAICS Crosswalk

SCC	SCC Name	SIC	NAICS
30500313	Mineral Products, Brick Manufacture, Curing and Firing: Coal-fired Tunnel Kilns	3251 Stone, Clay, and Glass Products	327 Wood Product Manufacturing; Nonmetallic Mineral Product Manufacturing
30500314	Mineral Products, Brick Manufacture, Curing and Firing: Gas-fired Periodic Kilns	3255 Stone, Clay, and Glass Products	327 Wood Product Manufacturing; Nonmetallic Mineral Product Manufacturing
30500398	Mineral Products, Brick Manufacture, Other Not Classified	3251 Stone, Clay, and Glass Products	327 Wood Product Manufacturing; Nonmetallic Mineral Product Manufacturing
30500402	Mineral Products, Calcium Carbide, Coke Dryer	2819 Chemicals and Allied Products	331 Primary Metal Manufacturing; Primary Metal Manufacturing
30500406	Mineral Products, Calcium Carbide, Circular Charging: Conveyor	2819 Chemicals and Allied Products	331 Primary Metal Manufacturing; Primary Metal Manufacturing
30500499	Mineral Products, Calcium Carbide, Other Not Classified	2819 Chemicals and Allied Products	331 Primary Metal Manufacturing; Primary Metal Manufacturing
30500606	Mineral Products, Cement Manufacturing (Dry Process), Kilns	3241 Stone, Clay, and Glass Products	327 Wood Product Manufacturing; Nonmetallic Mineral Product Manufacturing
30500609	Mineral Products, Cement Manufacturing (Dry Process), Primary Crushing	3241 Stone, Clay, and Glass Products	327 Wood Product Manufacturing; Nonmetallic Mineral Product Manufacturing
30500610	Mineral Products, Cement Manufacturing (Dry Process), Secondary Crushing	3241 Stone, Clay, and Glass Products	327 Wood Product Manufacturing; Nonmetallic Mineral Product Manufacturing
30500611	Mineral Products, Cement Manufacturing (Dry Process), Screening	3241 Stone, Clay, and Glass Products	327 Wood Product Manufacturing; Nonmetallic Mineral Product Manufacturing
30500612	Mineral Products, Cement Manufacturing (Dry Process), Raw Material Transfer	3241 Stone, Clay, and Glass Products	327 Wood Product Manufacturing; Nonmetallic Mineral Product Manufacturing
30500613	Mineral Products, Cement Manufacturing (Dry Process), Raw Material Grinding and Drying	3295 Stone, Clay, and Glass Products	212 Mining; Mining (except Oil and Gas)
30500614	Mineral Products, Cement Manufacturing (Dry Process), Clinker Cooler	3241 Stone, Clay, and Glass Products	327 Wood Product Manufacturing; Nonmetallic Mineral Product Manufacturing

SCC	SCC Name	SIC	NAICS
30500616	Mineral Products, Cement Manufacturing (Dry Process), Clinker Transfer	3241 Stone, Clay, and Glass Products	327 Wood Product Manufacturing; Nonmetallic Mineral Product Manufacturing
30500617	Mineral Products, Cement Manufacturing (Dry Process), Clinker Grinding	3241 Stone, Clay, and Glass Products	327 Wood Product Manufacturing; Nonmetallic Mineral Product Manufacturing
30500618	Mineral Products, Cement Manufacturing (Dry Process), Cement Silos	3241 Stone, Clay, and Glass Products	327 Wood Product Manufacturing; Nonmetallic Mineral Product Manufacturing
30500619	Mineral Products, Cement Manufacturing (Dry Process), Cement Load Out	3295 Stone, Clay, and Glass Products	212 Mining; Mining (except Oil and Gas)
30500706	Mineral Products, Cement Manufacturing (Wet Process), Kilns	3241 Stone, Clay, and Glass Products	327 Wood Product Manufacturing; Nonmetallic Mineral Product Manufacturing
10100202	Electric Generation, Bituminous/Subbituminous Coal, Pulverized Coal: Dry Bottom (Bituminous Coal)	4911 Electric, Gas, and Sanitary Services	221 Utilities; Utilities
10100203	Electric Generation, Bituminous/Subbituminous Coal, Cyclone Furnace (Bituminous Coal)	4911 Electric, Gas, and Sanitary Services	221 Utilities; Utilities
10100212	Electric Generation, Bituminous/Subbituminous Coal, Pulverized Coal: Dry Bottom (Tangential) (Bituminous Coal)	4911 Electric, Gas, and Sanitary Services	221 Utilities; Utilities
10100401	Electric Generation, Residual Oil, Grade 6 Oil: Normal Firing	4911 Electric, Gas, and Sanitary Services	221 Utilities; Utilities
10100404	Electric Generation, Residual Oil, Grade 6 Oil: Tangential Firing	4911 Electric, Gas, and Sanitary Services	221 Utilities; Utilities
10100501	Electric Generation, Distillate Oil, Grades 1 and 2 Oil	4911 Electric, Gas, and Sanitary Services	221 Utilities; Utilities
10100504	Electric Generation, Distillate Oil, Grade 4 Oil: Normal Firing	4911 Electric, Gas, and Sanitary Services	221 Utilities; Utilities
10100505	Electric Generation, Distillate Oil, Grade 4 Oil: Tangential Firing	4911 Electric, Gas, and Sanitary Services	221 Utilities; Utilities

SCC	SCC Name	SIC	NAICS
10100601	Electric Generation, Natural Gas, Boilers > 100 Million Btu/hr except Tangential	4911 Electric, Gas, and Sanitary Services	221 Utilities; Utilities
10100602	Electric Generation, Natural Gas, Boilers < 100 Million Btu/hr except Tangential	3674 Electronic & Other Electric Equipment	334 Primary Metal Manufacturing; Computer and Electronic Product Manufacturing
10100604	Electric Generation, Natural Gas, Tangentially Fired Units	4911 Electric, Gas, and Sanitary Services	221 Utilities; Utilities
10100701	Electric Generation, Process Gas, Boilers > 100 Million Btu/hr	3312 Primary Metal Industries	324 Wood Product Manufacturing; Petroleum and Coal Products Manufacturing
10100702	Electric Generation, Process Gas, Boilers < 100 Million Btu/hr	4952 Electric, Gas, and Sanitary Services	221 Utilities; Utilities
10100902	Electric Generation, Wood/Bark Waste, Wood/Bark Fired Boiler	9223 Justice, Public Order, and Safety	922 Public Administration; Justice, Public Order, and Safety Activities
10100903	Electric Generation, Wood/Bark Waste, Wood-fired Boiler	2511 Furniture and Fixtures	337 Primary Metal Manufacturing; Furniture and Related Product Manufacturing
10101201	Electric Generation, Solid Waste, Specify Waste Material in Comments	2511 Furniture and Fixtures	337 Primary Metal Manufacturing; Furniture and Related Product Manufacturing
10200201	Industrial, Bituminous/Subbituminous Coal, Pulverized Coal: Wet Bottom	4961 Electric, Gas, and Sanitary Services	221 Utilities; Utilities
10200202	Industrial, Bituminous/Subbituminous Coal, Pulverized Coal: Dry Bottom	2621 Paper and Allied Products	322 Wood Product Manufacturing; Paper Manufacturing
10200203	Industrial, Bituminous/Subbituminous Coal, Cyclone Furnace	3679 Electronic & Other Electric Equipment	334 Primary Metal Manufacturing; Computer and Electronic Product Manufacturing
10200204	Industrial, Bituminous/Subbituminous Coal, Spreader Stoker	2511 Furniture and Fixtures	337 Primary Metal Manufacturing; Furniture and Related Product Manufacturing
10200205	Industrial, Bituminous/Subbituminous Coal, Overfeed Stoker	8221 Educational Services	611 Educational Services; Educational Services

SCC	SCC Name	SIC	NAICS
10200206	Industrial, Bituminous/Subbituminous Coal, Underfeed Stoker	4961 Electric, Gas, and Sanitary Services	221 Utilities; Utilities
10200210	Industrial, Bituminous/Subbituminous Coal, Overfeed Stoker **	2435 Lumber and Wood Products	321 Wood Product Manufacturing; Wood Product Manufacturing
10200224	Industrial, Bituminous/Subbituminous Coal, Spreader Stoker (Subbituminous Coal)	2511 Furniture and Fixtures	337 Primary Metal Manufacturing; Furniture and Related Product Manufacturing
10200401	Industrial, Residual Oil, Grade 6 Oil	4961 Electric, Gas, and Sanitary Services	221 Utilities; Utilities
10200404	Industrial, Residual Oil, Grade 5 Oil	2731 Printing and Publishing	512 Information; Motion Picture and Sound Recording Industries
10200501	Industrial, Distillate Oil, Grades 1 and 2 Oil	4911 Electric, Gas, and Sanitary Services	221 Utilities; Utilities
10200504	Industrial, Distillate Oil, Grade 4 Oil	4911 Electric, Gas, and Sanitary Services	221 Utilities; Utilities
10200505	Industrial, Distillate Oil, Cogeneration	3519 Industrial Machinery and Equipment	333 Primary Metal Manufacturing; Machinery Manufacturing
10200601	Industrial, Natural Gas, > 100 Million Btu/hr	4961 Electric, Gas, and Sanitary Services	221 Utilities; Utilities
10200602	Industrial, Natural Gas, 10-100 Million Btu/hr	4961 Electric, Gas, and Sanitary Services	221 Utilities; Utilities
10200603	Industrial, Natural Gas, < 10 Million Btu/hr	3732 Transportation Equipment	811 Other Services (except Public Administration); Repair and Maintenance
10200701	Industrial, Process Gas, Petroleum Refinery Gas	2911 Petroleum and Coal Products	324 Wood Product Manufacturing; Petroleum and Coal Products Manufacturing
10200707	Industrial, Process Gas, Coke Oven Gas	3312 Primary Metal Industries	324 Wood Product Manufacturing; Petroleum and Coal Products Manufacturing

SCC	SCC Name	SIC	NAICS
10200901	Industrial, Wood/Bark Waste, Bark-fired Boiler (> 50,000 Lb Steam)	2621 Paper and Allied Products	322 Wood Product Manufacturing; Paper Manufacturing
10200902	Industrial, Wood/Bark Waste, Wood/Bark-fired Boiler (> 50,000 Lb Steam)	2421 Lumber and Wood Products	321 Wood Product Manufacturing; Wood Product Manufacturing
10200903	Industrial, Wood/Bark Waste, Wood-fired Boiler (> 50,000 Lb Steam)	2511 Furniture and Fixtures	337 Primary Metal Manufacturing; Furniture and Related Product Manufacturing
10200906	Industrial, Wood/Bark Waste, Wood-fired Boiler (< 50,000 Lb Steam)	2511 Furniture and Fixtures	337 Primary Metal Manufacturing; Furniture and Related Product Manufacturing
10201002	Industrial, Liquified Petroleum Gas (LPG), Propane	2657 Paper and Allied Products	322 Wood Product Manufacturing; Paper Manufacturing
10201201	Industrial, Solid Waste, Specify Waste Material in Comments	4953 Electric, Gas, and Sanitary Services	562 Administrative and Support and Waste Management and Remediation Services; Waste Management and Remediation Services
10201301	Industrial, Liquid Waste, Specify Waste Material in Comments	2512 Furniture and Fixtures	337 Primary Metal Manufacturing; Furniture and Related Product Manufacturing
10201302	Industrial, Liquid Waste, Waste Oil	2048 Food and Kindred Products	311 Food Manufacturing; Food Manufacturing
10300206	Commercial/Institutional, Bituminous/Subbituminous Coal, Pulverized Coal: Dry Bottom (Bituminous Coal)	9711 National Security and Intl. Affairs	928 Public Administration; National Security and International Affairs
10300207	Commercial/Institutional, Bituminous/Subbituminous Coal, Overfeed Stoker (Bituminous Coal)	8221 Educational Services	611 Educational Services; Educational Services
10300208	Commercial/Institutional, Bituminous/Subbituminous Coal, Underfeed Stoker (Bituminous Coal)	9223 Justice, Public Order, and Safety	922 Public Administration; Justice, Public Order, and Safety Activities
10300209	Commercial/Institutional, Bituminous/Subbituminous Coal, Spreader Stoker (Bituminous Coal)	4961 Electric, Gas, and Sanitary Services	221 Utilities; Utilities
10300211	Commercial/Institutional, Bituminous/Subbituminous Coal, Overfeed Stoker **	9223 Justice, Public Order, and Safety	922 Public Administration; Justice, Public Order, and Safety Activities

SCC	SCC Name	SIC	NAICS
10300217	Commercial/Institutional, Bituminous/Subbituminous Coal, Atmospheric Fluidized Bed Combustion: Bubbling Bed (Bituminous Coal)	8221 Educational Services	611 Educational Services; Educational Services
10300401	Commercial/Institutional, Residual Oil, Grade 6 Oil	4961 Electric, Gas, and Sanitary Services	221 Utilities; Utilities
10300402	Commercial/Institutional, Residual Oil, 10-100 Million Btu/hr **	9711 National Security and Intl. Affairs	928 Public Administration; National Security and International Affairs
10300404	Commercial/Institutional, Residual Oil, Grade 5 Oil	5171 Wholesale Trade - Nondurable Goods	422 Wholesale Trade; Wholesale Trade, Nondurable Goods
10300501	Commercial/Institutional, Distillate Oil, Grades 1 and 2 Oil	8733 Engineering & Management Services	541 Professional, Scientific, and Technical Services; Professional, Scientific, and Technical Services
10300502	Commercial/Institutional, Distillate Oil, 10-100 Million Btu/hr **	9711 National Security and Intl. Affairs	928 Public Administration; National Security and International Affairs
10300503	Commercial/Institutional, Distillate Oil, < 10 Million Btu/hr **	3273 Stone, Clay, and Glass Products	327 Wood Product Manufacturing; Nonmetallic Mineral Product Manufacturing
10300601	Commercial/Institutional, Natural Gas, > 100 Million Btu/hr	8221 Educational Services	611 Educational Services; Educational Services
10300602	Commercial/Institutional, Natural Gas, 10-100 Million Btu/hr	8733 Engineering & Management Services	541 Professional, Scientific, and Technical Services; Professional, Scientific, and Technical Services
10300603	Commercial/Institutional, Natural Gas, < 10 Million Btu/hr	7216 Personal Services	812 Other Services (except Public Administration); Personal and Laundry Services
10300701	Commercial/Institutional, Process Gas, POTW Digester Gas-fired Boiler	4952 Electric, Gas, and Sanitary Services	221 Utilities; Utilities
10300799	Commercial/Institutional, Process Gas, Other Not Classified	3312 Primary Metal Industries	324 Wood Product Manufacturing; Petroleum and Coal Products Manufacturing
10300903	Commercial/Institutional, Wood/Bark Waste, Wood-fired Boiler	2511 Furniture and Fixtures	337 Primary Metal Manufacturing; Furniture and Related Product Manufacturing

SCC	SCC Name	SIC	NAICS
10301002	Commercial/Institutional, Liquified Petroleum Gas (LPG), Propane	3585 Industrial Machinery and Equipment	333 Primary Metal Manufacturing; Machinery Manufacturing
10500105	Space Heaters, Industrial, Distillate Oil	3312 Primary Metal Industries	324 Wood Product Manufacturing; Petroleum and Coal Products Manufacturing
10500106	Space Heaters, Industrial, Natural Gas	3312 Primary Metal Industries	324 Wood Product Manufacturing; Petroleum and Coal Products Manufacturing
10500110	Space Heaters, Industrial, Liquified Petroleum Gas (LPG)	3312 Primary Metal Industries	324 Wood Product Manufacturing; Petroleum and Coal Products Manufacturing
10500210	Space Heaters, Commercial/Institutional, Liquified Petroleum Gas (LPG)	4931 Electric, Gas, and Sanitary Services	221 Utilities; Utilities
20100101	Electric Generation, Distillate Oil (Diesel), Turbine	4911 Electric, Gas, and Sanitary Services	221 Utilities; Utilities
20100102	Electric Generation, Distillate Oil (Diesel), Reciprocating	4911 Electric, Gas, and Sanitary Services	221 Utilities; Utilities
20100201	Electric Generation, Natural Gas, Turbine	4931 Electric, Gas, and Sanitary Services	221 Utilities; Utilities
20100702	Electric Generation, Process Gas, Reciprocating	4953 Electric, Gas, and Sanitary Services	562 Administrative and Support and Waste Management and Remediation Services; Waste Management and Remediation Services
20200104	Industrial, Distillate Oil (Diesel), Reciprocating: Cogeneration	4911 Electric, Gas, and Sanitary Services	221 Utilities; Utilities
20200202	Industrial, Natural Gas, Reciprocating	4922 Electric, Gas, and Sanitary Services	486 Air Transportation; Pipeline Transportation
20200401	Industrial, Large Bore Engine, Diesel	9711 National Security and Intl. Affairs	928 Public Administration; National Security and International Affairs
20300101	Commercial/Institutional, Distillate Oil (Diesel), Reciprocating	9711 National Security and Intl. Affairs	928 Public Administration; National Security and International Affairs

SCC	SCC Name	SIC	NAICS
20300102	Commercial/Institutional, Distillate Oil (Diesel), Turbine	9711 National Security and Intl. Affairs	928 Public Administration; National Security and International Affairs
30100101	Chemical Manufacturing, Adipic Acid, General	2869 Chemicals and Allied Products	325 Wood Product Manufacturing; Chemical Manufacturing
30100601	Chemical Manufacturing, Charcoal Manufacturing, General	2499 Lumber and Wood Products	339 Primary Metal Manufacturing; Miscellaneous Manufacturing
30100699	Chemical Manufacturing, Charcoal Manufacturing, Other Not Classified	2062 Food and Kindred Products	311 Food Manufacturing; Food Manufacturing
30100901	Chemical Manufacturing, Cleaning Chemicals, Spray Drying: Soaps and Detergents	2844 Chemicals and Allied Products	325 Wood Product Manufacturing; Chemical Manufacturing
30100902	Chemical Manufacturing, Cleaning Chemicals, Specialty Cleaners	2842 Chemicals and Allied Products	325 Wood Product Manufacturing; Chemical Manufacturing
30100999	Chemical Manufacturing, Cleaning Chemicals, Other Not Classified	2841 Chemicals and Allied Products	325 Wood Product Manufacturing; Chemical Manufacturing
30101011	Chemical Manufacturing, Explosives (Trinitrotoluene), Batch Process: Nitration Reactors Fume Recovery	2892 Chemicals and Allied Products	325 Wood Product Manufacturing; Chemical Manufacturing
30101301	Chemical Manufacturing, Nitric Acid, Absorber Tail Gas (Pre-1970 Facilities)	2892 Chemicals and Allied Products	325 Wood Product Manufacturing; Chemical Manufacturing
30101302	Chemical Manufacturing, Nitric Acid, Absorber Tail Gas (Post-1970 Facilities)	2892 Chemicals and Allied Products	325 Wood Product Manufacturing; Chemical Manufacturing
30101401	Chemical Manufacturing, Paint Manufacture, General Mixing and Handling	2911 Petroleum and Coal Products	324 Wood Product Manufacturing; Petroleum and Coal Products Manufacturing
30101402	Chemical Manufacturing, Paint Manufacture, Pigment Handling	2851 Chemicals and Allied Products	325 Wood Product Manufacturing; Chemical Manufacturing
30101503	Chemical Manufacturing, Varnish Manufacturing, Alkyd	2851 Chemicals and Allied Products	325 Wood Product Manufacturing; Chemical Manufacturing

SCC	SCC Name	SIC	NAICS
30101599	Chemical Manufacturing, Varnish Manufacturing, Other Not Classified	2851 Chemicals and Allied Products	325 Wood Product Manufacturing; Chemical Manufacturing
30101805	Chemical Manufacturing, Plastics Production, Phenolic Resins	3083 Rubber and Misc. Plastics Products	326 Wood Product Manufacturing; Plastics and Rubber Products Manufacturing
30101817	Chemical Manufacturing, Plastics Production, General	3086 Rubber and Misc. Plastics Products	326 Wood Product Manufacturing; Plastics and Rubber Products Manufacturing
30101842	Chemical Manufacturing, Plastics Production, Melamine Resins	3083 Rubber and Misc. Plastics Products	326 Wood Product Manufacturing; Plastics and Rubber Products Manufacturing
30101893	Chemical Manufacturing, Plastics Production, Raw Material Storage	2865 Chemicals and Allied Products	325 Wood Product Manufacturing; Chemical Manufacturing
30101899	Chemical Manufacturing, Plastics Production, Others Not Specified	2865 Chemicals and Allied Products	325 Wood Product Manufacturing; Chemical Manufacturing
30102001	Chemical Manufacturing, Printing Ink Manufacture, Vehicle Cooking: General	2891 Chemicals and Allied Products	325 Wood Product Manufacturing; Chemical Manufacturing
30102005	Chemical Manufacturing, Printing Ink Manufacture, Pigment Mixing	2893 Chemicals and Allied Products	325 Wood Product Manufacturing; Chemical Manufacturing
30102301	Chemical Manufacturing, Sulfuric Acid (Contact Process), Absorber/@ 99.9% Conversion	2892 Chemicals and Allied Products	325 Wood Product Manufacturing; Chemical Manufacturing
30102399	Chemical Manufacturing, Sulfuric Acid (Contact Process), Other Not Classified	2816 Chemicals and Allied Products	325 Wood Product Manufacturing; Chemical Manufacturing
30102599	Chemical Manufacturing, Cellulosic Fiber Production, Other Not Classified	2823 Chemicals and Allied Products	325 Wood Product Manufacturing; Chemical Manufacturing
30103202	Chemical Manufacturing, Elemental Sulfur Production, Mod. Claus: 3 Stage w/o Control (95-96% Removal)	2911 Petroleum and Coal Products	324 Wood Product Manufacturing; Petroleum and Coal Products Manufacturing
30103204	Chemical Manufacturing, Elemental Sulfur Production, Sulfur Removal Process (99.9% Removal)	4925 Electric, Gas, and Sanitary Services	221 Utilities; Utilities

SCC	SCC Name	SIC	NAICS
30103311	Chemical Manufacturing, Pesticides, General	2879 Chemicals and Allied Products	325 Wood Product Manufacturing; Chemical Manufacturing
30103501	Chemical Manufacturing, Inorganic Pigments, TiO2 Sulfate Process: Calciner	2816 Chemicals and Allied Products	325 Wood Product Manufacturing; Chemical Manufacturing
30103553	Chemical Manufacturing, Inorganic Pigments, Pigment Dryer	2816 Chemicals and Allied Products	325 Wood Product Manufacturing; Chemical Manufacturing
30103554	Chemical Manufacturing, Inorganic Pigments, Conveying/Storage/Packing	2819 Chemicals and Allied Products	331 Primary Metal Manufacturing; Primary Metal Manufacturing
30103599	Chemical Manufacturing, Inorganic Pigments, Other Not Classified	2816 Chemicals and Allied Products	325 Wood Product Manufacturing; Chemical Manufacturing
30104101	Chemical Manufacturing, Nitrocellulose, Nitration Reactor	2892 Chemicals and Allied Products	325 Wood Product Manufacturing; Chemical Manufacturing
30104104	Chemical Manufacturing, Nitrocellulose, Nitric Acid Concentrators	2892 Chemicals and Allied Products	325 Wood Product Manufacturing; Chemical Manufacturing
30104501	Chemical Manufacturing, Organic Fertilizer, General: Mixing/Handling	2819 Chemicals and Allied Products	331 Primary Metal Manufacturing; Primary Metal Manufacturing
30106099	Chemical Manufacturing, Pharmaceutical Preparations, Other Not Classified	2834 Chemicals and Allied Products	325 Wood Product Manufacturing; Chemical Manufacturing
30107002	Chemical Manufacturing, Inorganic Chemical Manufacturing (General), Storage/Transfer	5085 Wholesale Trade - Durable Goods	421 Wholesale Trade; Wholesale Trade, Durable Goods
30111299	Chemical Manufacturing, Elemental Phosphorous, Other Not Classified	2819 Chemicals and Allied Products	331 Primary Metal Manufacturing; Primary Metal Manufacturing
30113701	Chemical Manufacturing, Esters Production, Ethyl Acrylate	2869 Chemicals and Allied Products	325 Wood Product Manufacturing; Chemical Manufacturing
30121101	Chemical Manufacturing, Linear Alkylbenzene, Olefin Process: General	2841 Chemicals and Allied Products	325 Wood Product Manufacturing; Chemical Manufacturing

SCC	SCC Name	SIC	NAICS
30125004	Chemical Manufacturing, Methanol/Alcohol Production, Methanol: Fugitive Emissions	3546 Industrial Machinery and Equipment	333 Primary Metal Manufacturing; Machinery Manufacturing
30125880	Chemical Manufacturing, Benzene/Toluene/Aromatics/Xylenes, Aromatics: Fugitive Emissions	2841 Chemicals and Allied Products	325 Wood Product Manufacturing; Chemical Manufacturing
30182001	Chemical Manufacturing, Wastewater Treatment, Wastewater Stripper	2841 Chemicals and Allied Products	325 Wood Product Manufacturing; Chemical Manufacturing
30182002	Chemical Manufacturing, Wastewater Treatment, Wastewater Treatment	2865 Chemicals and Allied Products	325 Wood Product Manufacturing; Chemical Manufacturing
30188801	Chemical Manufacturing, Fugitive Emissions, Specify in Comments Field	2891 Chemicals and Allied Products	325 Wood Product Manufacturing; Chemical Manufacturing
30190011	Chemical Manufacturing, Fuel Fired Equipment, Distillate Oil (No. 2): Incinerators	2879 Chemicals and Allied Products	325 Wood Product Manufacturing; Chemical Manufacturing
30199998	Chemical Manufacturing, Other Not Classified, Specify in Comments Field	2819 Chemicals and Allied Products	331 Primary Metal Manufacturing; Primary Metal Manufacturing
30199999	Chemical Manufacturing, Other Not Classified, Specify in Comments Field	2819 Chemicals and Allied Products	331 Primary Metal Manufacturing; Primary Metal Manufacturing
30200504	Food and Agriculture, Feed and Grain Terminal Elevators, Drying	2851 Chemicals and Allied Products	325 Wood Product Manufacturing; Chemical Manufacturing
30200510	Food and Agriculture, Feed and Grain Terminal Elevators, Removal from Bins (Tunnel Belt)	3412 Fabricated Metal Products	332 Primary Metal Manufacturing; Fabricated Metal Product Manufacturing
30200604	Food and Agriculture, Feed and Grain Country Elevators, Drying	0254 Agricultural Production - Livestock	112 Agriculture, Forestry, Fishing and Hunting; Animal Production
30200742	Food and Agriculture, Grain Millings, Dry Corn Milling: Grain Drying	2048 Food and Kindred Products	311 Food Manufacturing; Food Manufacturing
30200743	Food and Agriculture, Grain Millings, Dry Corn Milling: Precleaning/Handling	2048 Food and Kindred Products	311 Food Manufacturing; Food Manufacturing

SCC	SCC Name	SIC	NAICS
30200745	Food and Agriculture, Grain Millings, Dry Corn Milling: Degerming and Milling	0254 Agricultural Production - Livestock	112 Agriculture, Forestry, Fishing and Hunting; Animal Production
30200788	Food and Agriculture, Grain Millings, Soybean: Flaking	2075 Food and Kindred Products	311 Food Manufacturing; Food Manufacturing
30200789	Food and Agriculture, Grain Millings, Soybean: Meal Dryer	2075 Food and Kindred Products	311 Food Manufacturing; Food Manufacturing
30200790	Food and Agriculture, Grain Millings, Soybean: Meal Cooler	2075 Food and Kindred Products	311 Food Manufacturing; Food Manufacturing
30200791	Food and Agriculture, Grain Millings, Soybean: Bulk Loading	2075 Food and Kindred Products	311 Food Manufacturing; Food Manufacturing
30200805	Food and Agriculture, Feed Manufacture, Grinding	2048 Food and Kindred Products	311 Food Manufacturing; Food Manufacturing
30200899	Food and Agriculture, Feed Manufacture, Not Classified **	3264 Stone, Clay, and Glass Products	327 Wood Product Manufacturing; Nonmetallic Mineral Product Manufacturing
30200903	Food and Agriculture, Beer Production, Brew Kettle ** (use SCC 3-02-009-07)	2082 Food and Kindred Products	312 Food Manufacturing; Beverage and Tobacco Product Manufacturing
30201003	Food and Agriculture, Distilled Spirits, Aging** (see 3-02-010-17)	2085 Food and Kindred Products	312 Food Manufacturing; Beverage and Tobacco Product Manufacturing
30201201	Food and Agriculture, Fish Processing, Cookers: Fresh Fish Scrap	2077 Food and Kindred Products	311 Food Manufacturing; Food Manufacturing
30201206	Food and Agriculture, Fish Processing, Direct Fired Dryer	2077 Food and Kindred Products	311 Food Manufacturing; Food Manufacturing
30201301	Food and Agriculture, Meat Smokehouses, Combined Operations **	2011 Food and Kindred Products	311 Food Manufacturing; Food Manufacturing
30201501	Food and Agriculture, Sugar Cane Refining, General	2062 Food and Kindred Products	311 Food Manufacturing; Food Manufacturing

SCC	SCC Name	SIC	NAICS
30201599	Food and Agriculture, Sugar Cane Refining, Other Not Classified	2062 Food and Kindred Products	311 Food Manufacturing; Food Manufacturing
30201903	Food and Agriculture, Vegetable Oil Processing, Soybean Oil: General **	2048 Food and Kindred Products	311 Food Manufacturing; Food Manufacturing
30201918	Food and Agriculture, Vegetable Oil Processing, Oil Refining	2048 Food and Kindred Products	311 Food Manufacturing; Food Manufacturing
30203001	Food and Agriculture, Dairy Products, Milk: Spray Dryer	2026 Food and Kindred Products	311 Food Manufacturing; Food Manufacturing
30203104	Food and Agriculture, Export Grain Elevators, Drying	5153 Wholesale Trade - Nondurable Goods	422 Wholesale Trade; Wholesale Trade, Nondurable Goods
30203105	Food and Agriculture, Export Grain Elevators, Unloading	0723 Agricultural Services	311 Food Manufacturing; Food Manufacturing
30203106	Food and Agriculture, Export Grain Elevators, Loading	0723 Agricultural Services	311 Food Manufacturing; Food Manufacturing
30203201	Food and Agriculture, Bakeries, Bread Baking: Sponge-Dough Process	2051 Food and Kindred Products	311 Food Manufacturing; Food Manufacturing
30203202	Food and Agriculture, Bakeries, Bread Baking: Straight-Dough Process	2051 Food and Kindred Products	311 Food Manufacturing; Food Manufacturing
30203299	Food and Agriculture, Bakeries, Other Not Classified	2051 Food and Kindred Products	311 Food Manufacturing; Food Manufacturing
30203801	Food and Agriculture, Animal/Poultry Rendering, General	2077 Food and Kindred Products	311 Food Manufacturing; Food Manufacturing
30288801	Food and Agriculture, Fugitive Emissions, Specify in Comments Field	2099 Food and Kindred Products	311 Food Manufacturing; Food Manufacturing
30299998	Food and Agriculture, Other Not Specified, Other Not Classified	2048 Food and Kindred Products	311 Food Manufacturing; Food Manufacturing

SCC	SCC Name	SIC	NAICS
30299999	Food and Agriculture, Other Not Specified, Other Not Classified	2099 Food and Kindred Products	311 Food Manufacturing; Food Manufacturing
30300101	Primary Metal Production, Aluminum Ore (Electro-reduction), Prebaked Reduction Cell	3334 Primary Metal Industries	331 Primary Metal Manufacturing; Primary Metal Manufacturing
39000489	In-process Fuel Use, Residual Oil, General	2077 Food and Kindred Products	311 Food Manufacturing; Food Manufacturing
39000499	In-process Fuel Use, Residual Oil, General	2077 Food and Kindred Products	311 Food Manufacturing; Food Manufacturing
39000503	In-process Fuel Use, Distillate Oil, Lime Kiln	3274 Stone, Clay, and Glass Products	327 Wood Product Manufacturing; Nonmetallic Mineral Product Manufacturing
39000589	In-process Fuel Use, Distillate Oil, General	2077 Food and Kindred Products	311 Food Manufacturing; Food Manufacturing
39000599	In-process Fuel Use, Distillate Oil, General	3312 Primary Metal Industries	324 Wood Product Manufacturing; Petroleum and Coal Products Manufacturing
39000699	In-process Fuel Use, Natural Gas, General	2511 Furniture and Fixtures	337 Primary Metal Manufacturing; Furniture and Related Product Manufacturing
39000701	In-process Fuel Use, Process Gas, Coke Oven or Blast Furnace	2911 Petroleum and Coal Products	324 Wood Product Manufacturing; Petroleum and Coal Products Manufacturing
40400116	Petroleum Liquids Storage (non-Refinery), Bulk Terminals, Gasoline RVP 13/10/7: Withdrawal Loss (67000 Bbl Cap.) - Float Rf Tnk	5171 Wholesale Trade - Nondurable Goods	422 Wholesale Trade; Wholesale Trade, Nondurable Goods
40400117	Petroleum Liquids Storage (non-Refinery), Bulk Terminals, Gasoline RVP 13/10/7: Withdrawal Loss (250000 Bbl Cap.) - Float Rf Tnk	5172 Wholesale Trade - Nondurable Goods	422 Wholesale Trade; Wholesale Trade, Nondurable Goods
40400153	Petroleum Liquids Storage (non-Refinery), Bulk Terminals, Vapor Control Unit Losses	5171 Wholesale Trade - Nondurable Goods	422 Wholesale Trade; Wholesale Trade, Nondurable Goods
40400154	Petroleum Liquids Storage (non-Refinery), Bulk Terminals, Tank Truck Vapor Leaks	5171 Wholesale Trade - Nondurable Goods	422 Wholesale Trade; Wholesale Trade, Nondurable Goods

SCC	SCC Name	SIC	NAICS
30903005	Fabricated Metal Products, Machining Operations, Sawing: Specify Material in Comments	3559 Industrial Machinery and Equipment	332 Primary Metal Manufacturing; Fabricated Metal Product Manufacturing
30904001	Fabricated Metal Products, Metal Deposition Processes, Metallizing: Wire Atomization and Spraying	3728 Transportation Equipment	541 Professional, Scientific, and Technical Services; Professional, Scientific, and Technical Services
30904010	Fabricated Metal Products, Metal Deposition Processes, Thermal Spraying of Powdered Metal	3546 Industrial Machinery and Equipment	333 Primary Metal Manufacturing; Machinery Manufacturing
30988801	Fabricated Metal Products, Fugitive Emissions, Specify in Comments Field	3564 Industrial Machinery and Equipment	333 Primary Metal Manufacturing; Machinery Manufacturing
30990001	Fabricated Metal Products, Fuel Fired Equipment, Distillate Oil (No. 2): Process Heaters	3812 Instruments and Related Products	334 Primary Metal Manufacturing; Computer and Electronic Product Manufacturing
39000899	In-process Fuel Use, Coke, General: Coke	3321 Primary Metal Industries	331 Primary Metal Manufacturing; Primary Metal Manufacturing
39000989	In-process Fuel Use, Wood, General	3433 Fabricated Metal Products	333 Primary Metal Manufacturing; Machinery Manufacturing
39000999	In-process Fuel Use, Wood, General: Wood	2421 Lumber and Wood Products	321 Wood Product Manufacturing; Wood Product Manufacturing
39001089	In-process Fuel Use, Liquified Petroleum Gas, General	3321 Primary Metal Industries	331 Primary Metal Manufacturing; Primary Metal Manufacturing
39001099	In-process Fuel Use, Liquified Petroleum Gas, General	3411 Fabricated Metal Products	332 Primary Metal Manufacturing; Fabricated Metal Product Manufacturing
39001299	In-process Fuel Use, Solid Waste, General	2911 Petroleum and Coal Products	324 Wood Product Manufacturing; Petroleum and Coal Products Manufacturing
39001399	In-process Fuel Use, Liquid Waste, General	3295 Stone, Clay, and Glass Products	212 Mining; Mining (except Oil and Gas)
39999993	Miscellaneous Manufacturing Industries, Miscellaneous Industrial Processes, Other Not Classified	3812 Instruments and Related Products	334 Primary Metal Manufacturing; Computer and Electronic Product Manufacturing

SCC	SCC Name	SIC	NAICS
30501522	Mineral Products, Gypsum Manufacture, End Sawing (12 Ft.)	3275 Stone, Clay, and Glass Products	327 Wood Product Manufacturing; Nonmetallic Mineral Product Manufacturing
30501603	Mineral Products, Lime Manufacture, Calcining: Vertical Kiln	3274 Stone, Clay, and Glass Products	327 Wood Product Manufacturing; Nonmetallic Mineral Product Manufacturing
30501604	Mineral Products, Lime Manufacture, Calcining: Rotary Kiln ** (See SCC Codes 3-05-016-18,-19,-20,-21)	3274 Stone, Clay, and Glass Products	327 Wood Product Manufacturing; Nonmetallic Mineral Product Manufacturing
30501605	Mineral Products, Lime Manufacture, Calcining: Gas-fired Calcimatic Kiln	3274 Stone, Clay, and Glass Products	327 Wood Product Manufacturing; Nonmetallic Mineral Product Manufacturing
30501613	Mineral Products, Lime Manufacture, Lime Silos	3411 Fabricated Metal Products	332 Primary Metal Manufacturing; Fabricated Metal Product Manufacturing
30501905	Mineral Products, Phosphate Rock, Calcining	2048 Food and Kindred Products	311 Food Manufacturing; Food Manufacturing
30502001	Mineral Products, Stone Quarrying - Processing (See also 305320), Primary Crushing	3273 Stone, Clay, and Glass Products	327 Wood Product Manufacturing; Nonmetallic Mineral Product Manufacturing
30502002	Mineral Products, Stone Quarrying - Processing (See also 305320), Secondary Crushing/Screening	3295 Stone, Clay, and Glass Products	212 Mining; Mining (except Oil and Gas)
30502003	Mineral Products, Stone Quarrying - Processing (See also 305320), Tertiary Crushing/Screening	3273 Stone, Clay, and Glass Products	327 Wood Product Manufacturing; Nonmetallic Mineral Product Manufacturing
30502006	Mineral Products, Stone Quarrying - Processing (See also 305320), Miscellaneous Operations: Screen/Convey/Handling	3273 Stone, Clay, and Glass Products	327 Wood Product Manufacturing; Nonmetallic Mineral Product Manufacturing
30502012	Mineral Products, Stone Quarrying - Processing (See also 305320), Drying	3273 Stone, Clay, and Glass Products	327 Wood Product Manufacturing; Nonmetallic Mineral Product Manufacturing
30502510	Mineral Products, Construction Sand and Gravel, Crushing	2823 Chemicals and Allied Products	325 Wood Product Manufacturing; Chemical Manufacturing
30504021	Mineral Products, Mining and Quarrying of Nonmetallic Minerals, Convey/Haul Material	1422 Nonmetallic Minerals, Except Fuels	212 Mining; Mining (except Oil and Gas)

SCC	SCC Name	SIC	NAICS
30504030	Mineral Products, Mining and Quarrying of Nonmetallic Minerals, Primary Crusher	1422 Nonmetallic Minerals, Except Fuels	212 Mining; Mining (except Oil and Gas)
30504031	Mineral Products, Mining and Quarrying of Nonmetallic Minerals, Secondary Crusher	1422 Nonmetallic Minerals, Except Fuels	212 Mining; Mining (except Oil and Gas)
30510196	Mineral Products, Bulk Materials Conveyors, Chemical: Specify in Comments	3996 Miscellaneous Manufacturing Industries	326 Wood Product Manufacturing; Plastics and Rubber Products Manufacturing
30510202	Mineral Products, Bulk Materials Storage Bins, Cement	2891 Chemicals and Allied Products	325 Wood Product Manufacturing; Chemical Manufacturing
30300104	Primary Metal Production, Aluminum Ore (Electro-reduction), Materials Handling	3334 Primary Metal Industries	331 Primary Metal Manufacturing; Primary Metal Manufacturing
30300105	Primary Metal Production, Aluminum Ore (Electro-reduction), Anode Baking Furnace	3334 Primary Metal Industries	331 Primary Metal Manufacturing; Primary Metal Manufacturing
30300302	Primary Metal Production, By-product Coke Manufacturing, Oven Charging	3312 Primary Metal Industries	324 Wood Product Manufacturing; Petroleum and Coal Products Manufacturing
30300315	Primary Metal Production, By-product Coke Manufacturing, Gas By-product Plant	3312 Primary Metal Industries	324 Wood Product Manufacturing; Petroleum and Coal Products Manufacturing
30300615	Primary Metal Production, Ferroalloy, Open Furnace, Ferromanganese: Blast Furnace	2819 Chemicals and Allied Products	331 Primary Metal Manufacturing; Primary Metal Manufacturing
30300808	Primary Metal Production, Iron Production (See 3-03-015 for Integrated Iron & Steel MACT), Slag Crushing and Sizing	3295 Stone, Clay, and Glass Products	212 Mining; Mining (except Oil and Gas)
30300819	Primary Metal Production, Iron Production (See 3-03-015 for Integrated Iron & Steel MACT), Sinter Process (Combined Code includes 15,16,17,18)	3312 Primary Metal Industries	324 Wood Product Manufacturing; Petroleum and Coal Products Manufacturing
30300825	Primary Metal Production, Iron Production (See 3-03-015 for Integrated Iron & Steel MACT), Cast House	3312 Primary Metal Industries	324 Wood Product Manufacturing; Petroleum and Coal Products Manufacturing
30300841	Primary Metal Production, Iron Production (See 3-03-015 for Integrated Iron & Steel MACT), Flue Dust Unloading	3312 Primary Metal Industries	324 Wood Product Manufacturing; Petroleum and Coal Products Manufacturing

SCC	SCC Name	SIC	NAICS
30300901	Primary Metal Production, Steel Manufacturing (See 3-03-015 for Integrated Iron & Steel MACT), Open Hearth Furnace: Stack	3312 Primary Metal Industries	324 Wood Product Manufacturing; Petroleum and Coal Products Manufacturing
30300904	Primary Metal Production, Steel Manufacturing (See 3-03-015 for Integrated Iron & Steel MACT), Electric Arc Furnace: Alloy Steel (Stack)	3312 Primary Metal Industries	324 Wood Product Manufacturing; Petroleum and Coal Products Manufacturing
30300908	Primary Metal Production, Steel Manufacturing (See 3-03-015 for Integrated Iron & Steel MACT), Electric Arc Furnace: Carbon Steel (Stack)	3312 Primary Metal Industries	324 Wood Product Manufacturing; Petroleum and Coal Products Manufacturing
30300910	Primary Metal Production, Steel Manufacturing (See 3-03-015 for Integrated Iron & Steel MACT), Pickling	3312 Primary Metal Industries	324 Wood Product Manufacturing; Petroleum and Coal Products Manufacturing
30300912	Primary Metal Production, Steel Manufacturing (See 3-03-015 for Integrated Iron & Steel MACT), Grinding	3312 Primary Metal Industries	324 Wood Product Manufacturing; Petroleum and Coal Products Manufacturing
30300913	Primary Metal Production, Steel Manufacturing (See 3-03-015 for Integrated Iron & Steel MACT), Basic Oxygen Furnace: Open Hood-Stack	3312 Primary Metal Industries	324 Wood Product Manufacturing; Petroleum and Coal Products Manufacturing
30300922	Primary Metal Production, Steel Manufacturing (See 3-03-015 for Integrated Iron & Steel MACT), Continuous Casting	3312 Primary Metal Industries	324 Wood Product Manufacturing; Petroleum and Coal Products Manufacturing
30300931	Primary Metal Production, Steel Manufacturing (See 3-03-015 for Integrated Iron & Steel MACT), Hot Rolling	3312 Primary Metal Industries	324 Wood Product Manufacturing; Petroleum and Coal Products Manufacturing
30300933	Primary Metal Production, Steel Manufacturing (See 3-03-015 for Integrated Iron & Steel MACT), Reheat Furnaces	3312 Primary Metal Industries	324 Wood Product Manufacturing; Petroleum and Coal Products Manufacturing
30300934	Primary Metal Production, Steel Manufacturing (See 3-03-015 for Integrated Iron & Steel MACT), Heat Treating Furnaces: Annealing	3312 Primary Metal Industries	324 Wood Product Manufacturing; Petroleum and Coal Products Manufacturing
30300935	Primary Metal Production, Steel Manufacturing (See 3-03-015 for Integrated Iron & Steel MACT), Cold Rolling	3312 Primary Metal Industries	324 Wood Product Manufacturing; Petroleum and Coal Products Manufacturing
30300936	Primary Metal Production, Steel Manufacturing (See 3-03-015 for Integrated Iron & Steel MACT), Coating: Tin, Zinc, etc.	3312 Primary Metal Industries	324 Wood Product Manufacturing; Petroleum and Coal Products Manufacturing
30300999	Primary Metal Production, Steel Manufacturing (See 3-03-015 for Integrated Iron & Steel MACT), Other Not Classified	3312 Primary Metal Industries	324 Wood Product Manufacturing; Petroleum and Coal Products Manufacturing

SCC	SCC Name	SIC	NAICS
30301201	Primary Metal Production, Titanium, Chlorination	2816 Chemicals and Allied Products	325 Wood Product Manufacturing; Chemical Manufacturing
30390003	Primary Metal Production, Fuel Fired Equipment, Natural Gas: Process Heaters	3334 Primary Metal Industries	331 Primary Metal Manufacturing; Primary Metal Manufacturing
30390014	Primary Metal Production, Fuel Fired Equipment, Process Gas: Incinerators	3695 Electronic & Other Electric Equipment	334 Primary Metal Manufacturing; Computer and Electronic Product Manufacturing
30400102	Secondary Metal Production, Aluminum, Smelting Furnace/Crucible	3471 Fabricated Metal Products	332 Primary Metal Manufacturing; Fabricated Metal Product Manufacturing
30400103	Secondary Metal Production, Aluminum, Smelting Furnace/Reverberatory	3334 Primary Metal Industries	331 Primary Metal Manufacturing; Primary Metal Manufacturing
30400120	Secondary Metal Production, Aluminum, Can Manufacture	3411 Fabricated Metal Products	332 Primary Metal Manufacturing; Fabricated Metal Product Manufacturing
30400220	Secondary Metal Production, Copper, Charge with Copper: Electric Arc Furnace	3331 Primary Metal Industries	331 Primary Metal Manufacturing; Primary Metal Manufacturing
30400299	Secondary Metal Production, Copper, Other Not Classified	3331 Primary Metal Industries	331 Primary Metal Manufacturing; Primary Metal Manufacturing
30400301	Secondary Metal Production, Grey Iron Foundries, Cupola	3321 Primary Metal Industries	331 Primary Metal Manufacturing; Primary Metal Manufacturing
30400303	Secondary Metal Production, Grey Iron Foundries, Electric Induction Furnace	3334 Primary Metal Industries	331 Primary Metal Manufacturing; Primary Metal Manufacturing
30400310	Secondary Metal Production, Grey Iron Foundries, Inoculation	3321 Primary Metal Industries	331 Primary Metal Manufacturing; Primary Metal Manufacturing
30400320	Secondary Metal Production, Grey Iron Foundries, Pouring/Casting	3321 Primary Metal Industries	331 Primary Metal Manufacturing; Primary Metal Manufacturing
30400331	Secondary Metal Production, Grey Iron Foundries, Casting Shakeout	3321 Primary Metal Industries	331 Primary Metal Manufacturing; Primary Metal Manufacturing

SCC	SCC Name	SIC	NAICS
30400333	Secondary Metal Production, Grey Iron Foundries, Shakeout Machine	3321 Primary Metal Industries	331 Primary Metal Manufacturing; Primary Metal Manufacturing
30400340	Secondary Metal Production, Grey Iron Foundries, Grinding/Cleaning	3321 Primary Metal Industries	331 Primary Metal Manufacturing; Primary Metal Manufacturing
30400350	Secondary Metal Production, Grey Iron Foundries, Sand Grinding/Handling	3321 Primary Metal Industries	331 Primary Metal Manufacturing; Primary Metal Manufacturing
30400351	Secondary Metal Production, Grey Iron Foundries, Core Ovens	3321 Primary Metal Industries	331 Primary Metal Manufacturing; Primary Metal Manufacturing
30400352	Secondary Metal Production, Grey Iron Foundries, Sand Grinding/Handling	3321 Primary Metal Industries	331 Primary Metal Manufacturing; Primary Metal Manufacturing
30400527	Secondary Metal Production, Lead Battery Manufacture, Small Parts Casting	3812 Instruments and Related Products	334 Primary Metal Manufacturing; Computer and Electronic Product Manufacturing
30400701	Secondary Metal Production, Steel Foundries, Electric Arc Furnace	4011 Railroad Transportation	482 Air Transportation; Rail Transportation
30400716	Secondary Metal Production, Steel Foundries, Sand Grinding/Handling	3559 Industrial Machinery and Equipment	332 Primary Metal Manufacturing; Fabricated Metal Product Manufacturing
30400731	Secondary Metal Production, Steel Foundries, Core Machines/Other	3559 Industrial Machinery and Equipment	332 Primary Metal Manufacturing; Fabricated Metal Product Manufacturing
30405001	Secondary Metal Production, Miscellaneous Casting Fabricating, Other Not Classified	9711 National Security and Intl. Affairs	928 Public Administration; National Security and International Affairs
30490013	Secondary Metal Production, Fuel Fired Equipment, Natural Gas: Incinerators	5085 Wholesale Trade - Durable Goods	421 Wholesale Trade; Wholesale Trade, Durable Goods
30499999	Secondary Metal Production, Other Not Classified, Specify in Comments Field	2819 Chemicals and Allied Products	331 Primary Metal Manufacturing; Primary Metal Manufacturing
30500102	Mineral Products, Asphalt Roofing Manufacture, Asphalt Blowing: Coating (Use 3-05-050-10 for MACT)	2952 Petroleum and Coal Products	324 Wood Product Manufacturing; Petroleum and Coal Products Manufacturing

SCC	SCC Name	SIC	NAICS
30500111	Mineral Products, Asphalt Roofing Manufacture, Dipping Only	2952 Petroleum and Coal Products	324 Wood Product Manufacturing; Petroleum and Coal Products Manufacturing
30500198	Mineral Products, Asphalt Roofing Manufacture, Other Not Classified	2952 Petroleum and Coal Products	324 Wood Product Manufacturing; Petroleum and Coal Products Manufacturing
30500201	Mineral Products, Asphalt Concrete, Rotary Dryer: Conventional Plant (see 3-05-002-50 -51 -52 for subtypes)	1422 Nonmetallic Minerals, Except Fuels	212 Mining; Mining (except Oil and Gas)
30500202	Mineral Products, Asphalt Concrete, Hot Elevators, Screens, Bins and Mixer	2952 Petroleum and Coal Products	324 Wood Product Manufacturing; Petroleum and Coal Products Manufacturing
30500203	Mineral Products, Asphalt Concrete, Storage Piles	2951 Petroleum and Coal Products	324 Wood Product Manufacturing; Petroleum and Coal Products Manufacturing
30500204	Mineral Products, Asphalt Concrete, Cold Aggregate Handling	2951 Petroleum and Coal Products	324 Wood Product Manufacturing; Petroleum and Coal Products Manufacturing
30500205	Mineral Products, Asphalt Concrete, Drum Dryer: Hot Asphalt Plants (see 3-05-002-55 & -58 for subtypes)	1422 Nonmetallic Minerals, Except Fuels	212 Mining; Mining (except Oil and Gas)
30500208	Mineral Products, Asphalt Concrete, Asphalt Heater: Distillate Oil (Use 3-05-050-22 for MACT)	2951 Petroleum and Coal Products	324 Wood Product Manufacturing; Petroleum and Coal Products Manufacturing
30500301	Mineral Products, Brick Manufacture, Raw Material Drying	3251 Stone, Clay, and Glass Products	327 Wood Product Manufacturing; Nonmetallic Mineral Product Manufacturing
30500302	Mineral Products, Brick Manufacture, Raw Material Grinding & Screening	3297 Stone, Clay, and Glass Products	327 Wood Product Manufacturing; Nonmetallic Mineral Product Manufacturing
30500311	Mineral Products, Brick Manufacture, Curing and Firing: Gas-fired Tunnel Kilns	3255 Stone, Clay, and Glass Products	327 Wood Product Manufacturing; Nonmetallic Mineral Product Manufacturing
30500312	Mineral Products, Brick Manufacture, Curing and Firing: Oil-fired Tunnel Kilns	3297 Stone, Clay, and Glass Products	327 Wood Product Manufacturing; Nonmetallic Mineral Product Manufacturing
30500714	Mineral Products, Cement Manufacturing (Wet Process), Clinker Cooler	3241 Stone, Clay, and Glass Products	327 Wood Product Manufacturing; Nonmetallic Mineral Product Manufacturing

SCC	SCC Name	SIC	NAICS
30500718	Mineral Products, Cement Manufacturing (Wet Process), Cement Silos	3241 Stone, Clay, and Glass Products	327 Wood Product Manufacturing; Nonmetallic Mineral Product Manufacturing
30500719	Mineral Products, Cement Manufacturing (Wet Process), Cement Load Out	3241 Stone, Clay, and Glass Products	327 Wood Product Manufacturing; Nonmetallic Mineral Product Manufacturing
30500799	Mineral Products, Cement Manufacturing (Wet Process), Other Not Classified	1422 Nonmetallic Minerals, Except Fuels	212 Mining; Mining (except Oil and Gas)
30500802	Mineral Products, Ceramic Clay/Tile Manufacture, Comminution - Crushing, Grinding, & Milling	3264 Stone, Clay, and Glass Products	327 Wood Product Manufacturing; Nonmetallic Mineral Product Manufacturing
30500899	Mineral Products, Ceramic Clay/Tile Manufacture, Other Not Classified	3264 Stone, Clay, and Glass Products	327 Wood Product Manufacturing; Nonmetallic Mineral Product Manufacturing
30500999	Mineral Products, Clay and Fly Ash Sintering, Other Not Classified	2952 Petroleum and Coal Products	324 Wood Product Manufacturing; Petroleum and Coal Products Manufacturing
30501001	Mineral Products, Coal Mining, Cleaning, and Material Handling (See 305310), Fluidized Bed	1221 Coal Mining	212 Mining; Mining (except Oil and Gas)
30501010	Mineral Products, Coal Mining, Cleaning, and Material Handling (See 305310), Crushing	3295 Stone, Clay, and Glass Products	212 Mining; Mining (except Oil and Gas)
30501101	Mineral Products, Concrete Batching, General (Non-fugitive)	3531 Industrial Machinery and Equipment	336 Primary Metal Manufacturing; Transportation Equipment Manufacturing
30501109	Mineral Products, Concrete Batching, Mixer Loading of Cement/Sand/Aggregate	3295 Stone, Clay, and Glass Products	212 Mining; Mining (except Oil and Gas)
30501112	Mineral Products, Concrete Batching, Mixing: Wet	2951 Petroleum and Coal Products	324 Wood Product Manufacturing; Petroleum and Coal Products Manufacturing
30990003	Fabricated Metal Products, Fuel Fired Equipment, Natural Gas: Process Heaters	5085 Wholesale Trade - Durable Goods	421 Wholesale Trade; Wholesale Trade, Durable Goods
30990013	Fabricated Metal Products, Fuel Fired Equipment, Natural Gas: Incinerators	3586 Industrial Machinery and Equipment	333 Primary Metal Manufacturing; Machinery Manufacturing

SCC	SCC Name	SIC	NAICS
30999999	Fabricated Metal Products, Other Not Classified, Other Not Classified	3812 Instruments and Related Products	334 Primary Metal Manufacturing; Computer and Electronic Product Manufacturing
31000404	Oil and Gas Production, Process Heaters, Natural Gas	4925 Electric, Gas, and Sanitary Services	221 Utilities; Utilities
31299999	Machinery, Miscellaneous, Miscellaneous Machinery, Other Not Classified	9711 National Security and Intl. Affairs	928 Public Administration; National Security and International Affairs
31401002	Transportation Equipment, Brake Shoe Debonding, Multiple Chamber Incinerator	3714 Transportation Equipment	336 Primary Metal Manufacturing; Transportation Equipment Manufacturing
31499999	Transportation Equipment, Other Not Classified, Other Not Classified	3728 Transportation Equipment	541 Professional, Scientific, and Technical Services; Professional, Scientific, and Technical Services
32099998	Leather and Leather Products, Other Not Classified, Other Not Classified	3143 Leather and Leather Products	316 Food Manufacturing; Leather and Allied Product Manufacturing
32099999	Leather and Leather Products, Other Not Classified, Other Not Classified	3143 Leather and Leather Products	316 Food Manufacturing; Leather and Allied Product Manufacturing
33000103	Textile Products, Miscellaneous, Polyester Thread Production	3081 Rubber and Misc. Plastics Products	326 Wood Product Manufacturing; Plastics and Rubber Products Manufacturing
33000104	Textile Products, Miscellaneous, Tenter Frames: Heat Setting	2241 Textile Mill Products	313 Food Manufacturing; Textile Mills
33000199	Textile Products, Miscellaneous, Other Not Classified	2221 Textile Mill Products	313 Food Manufacturing; Textile Mills
33000202	Textile Products, Rubberized Fabrics, Wet Coating: General **	2823 Chemicals and Allied Products	325 Wood Product Manufacturing; Chemical Manufacturing
33000212	Textile Products, Rubberized Fabrics, Wet Coating	3999 Miscellaneous Manufacturing Industries	337 Primary Metal Manufacturing; Furniture and Related Product Manufacturing
33000298	Textile Products, Rubberized Fabrics, Other Not Classified	3143 Leather and Leather Products	316 Food Manufacturing; Leather and Allied Product Manufacturing

SCC	SCC Name	SIC	NAICS
33000499	Textile Products, Fabric Finishing, Other Not Classified	3081 Rubber and Misc. Plastics Products	326 Wood Product Manufacturing; Plastics and Rubber Products Manufacturing
33088801	Textile Products, Fugitive Emissions, Specify in Comments Field	3082 Rubber and Misc. Plastics Products	326 Wood Product Manufacturing; Plastics and Rubber Products Manufacturing
39000203	In-process Fuel Use, Bituminous Coal, Lime Kiln (Bituminous)	3274 Stone, Clay, and Glass Products	327 Wood Product Manufacturing; Nonmetallic Mineral Product Manufacturing
39999995	Miscellaneous Manufacturing Industries, Miscellaneous Industrial Processes, Other Not Classified	3679 Electronic & Other Electric Equipment	334 Primary Metal Manufacturing; Computer and Electronic Product Manufacturing
39999998	Miscellaneous Manufacturing Industries, Miscellaneous Industrial Processes, Other Not Classified	3812 Instruments and Related Products	334 Primary Metal Manufacturing; Computer and Electronic Product Manufacturing
39999999	Miscellaneous Manufacturing Industries, Miscellaneous Industrial Processes, See Comment **	3674 Electronic & Other Electric Equipment	334 Primary Metal Manufacturing; Computer and Electronic Product Manufacturing
40100101	Organic Solvent Evaporation, Dry Cleaning, Perchloroethylene	9711 National Security and Intl. Affairs	928 Public Administration; National Security and International Affairs
40100102	Organic Solvent Evaporation, Dry Cleaning, Stoddard (Petroleum Solvent) ** (Use 4-10-001-01 or 4-10-002-01)	9711 National Security and Intl. Affairs	928 Public Administration; National Security and International Affairs
30800702	Rubber and Miscellaneous Plastics Products, Fiberglass Resin Products, Mould Release	3086 Rubber and Misc. Plastics Products	326 Wood Product Manufacturing; Plastics and Rubber Products Manufacturing
30800703	Rubber and Miscellaneous Plastics Products, Fiberglass Resin Products, Solvent Consumption	3083 Rubber and Misc. Plastics Products	326 Wood Product Manufacturing; Plastics and Rubber Products Manufacturing
30800704	Rubber and Miscellaneous Plastics Products, Fiberglass Resin Products, Adhesive Consumption	3081 Rubber and Misc. Plastics Products	326 Wood Product Manufacturing; Plastics and Rubber Products Manufacturing
30800720	Rubber and Miscellaneous Plastics Products, Fiberglass Resin Products, General	3083 Rubber and Misc. Plastics Products	326 Wood Product Manufacturing; Plastics and Rubber Products Manufacturing
30800722	Rubber and Miscellaneous Plastics Products, Fiberglass Resin Products, Gel Coat: Spray On	3732 Transportation Equipment	811 Other Services (except Public Administration); Repair and Maintenance

SCC	SCC Name	SIC	NAICS
30800723	Rubber and Miscellaneous Plastics Products, Fiberglass Resin Products, Resin: General: Roll On	3732 Transportation Equipment	811 Other Services (except Public Administration); Repair and Maintenance
30800724	Rubber and Miscellaneous Plastics Products, Fiberglass Resin Products, Resin: General: Spray On ** (use 3-08-007-30)	3732 Transportation Equipment	811 Other Services (except Public Administration); Repair and Maintenance
30800799	Rubber and Miscellaneous Plastics Products, Fiberglass Resin Products, Other Not Classified	3531 Industrial Machinery and Equipment	336 Primary Metal Manufacturing; Transportation Equipment Manufacturing
30899999	Rubber and Miscellaneous Plastics Products, Other Not Specified, Other Not Classified	7549 Auto Repair, Services, and Parking	488 Air Transportation; Support Activities for Transportation
30900198	Fabricated Metal Products, General Processes, Other Not Classified	3442 Fabricated Metal Products	332 Primary Metal Manufacturing; Fabricated Metal Product Manufacturing
30900199	Fabricated Metal Products, General Processes, Other Not Classified	3479 Fabricated Metal Products	332 Primary Metal Manufacturing; Fabricated Metal Product Manufacturing
30900201	Fabricated Metal Products, Abrasive Blasting of Metal Parts, General	3731 Transportation Equipment	336 Primary Metal Manufacturing; Transportation Equipment Manufacturing
30900202	Fabricated Metal Products, Abrasive Blasting of Metal Parts, Sand Abrasive	3812 Instruments and Related Products	334 Primary Metal Manufacturing; Computer and Electronic Product Manufacturing
30900203	Fabricated Metal Products, Abrasive Blasting of Metal Parts, Slag Abrasive	3731 Transportation Equipment	336 Primary Metal Manufacturing; Transportation Equipment Manufacturing
30900205	Fabricated Metal Products, Abrasive Blasting of Metal Parts, Steel Grit Abrasive	3812 Instruments and Related Products	334 Primary Metal Manufacturing; Computer and Electronic Product Manufacturing
30900207	Fabricated Metal Products, Abrasive Blasting of Metal Parts, Shotblast with Air	3264 Stone, Clay, and Glass Products	327 Wood Product Manufacturing; Nonmetallic Mineral Product Manufacturing
30900299	Fabricated Metal Products, Abrasive Blasting of Metal Parts, General	3743 Transportation Equipment	333 Primary Metal Manufacturing; Machinery Manufacturing
30900303	Fabricated Metal Products, Abrasive Cleaning of Metal Parts, Polishing	3731 Transportation Equipment	336 Primary Metal Manufacturing; Transportation Equipment Manufacturing

SCC	SCC Name	SIC	NAICS
30900304	Fabricated Metal Products, Abrasive Cleaning of Metal Parts, Buffing	3589 Industrial Machinery and Equipment	333 Primary Metal Manufacturing; Machinery Manufacturing
30901001	Fabricated Metal Products, Electroplating Operations, Entire Process: General	9711 National Security and Intl. Affairs	928 Public Administration; National Security and International Affairs
30901098	Fabricated Metal Products, Electroplating Operations, Other Not Classified	2754 Printing and Publishing	323 Wood Product Manufacturing; Printing and Related Support Activities
30901101	Fabricated Metal Products, Conversion Coating of Metal Products, Alkaline Cleaning Bath	3589 Industrial Machinery and Equipment	333 Primary Metal Manufacturing; Machinery Manufacturing
30901102	Fabricated Metal Products, Conversion Coating of Metal Products, Acid Cleaning Bath (Pickling)	3829 Instruments and Related Products	334 Primary Metal Manufacturing; Computer and Electronic Product Manufacturing
30901104	Fabricated Metal Products, Conversion Coating of Metal Products, Rinsing/Finishing	3496 Fabricated Metal Products	332 Primary Metal Manufacturing; Fabricated Metal Product Manufacturing
30902501	Fabricated Metal Products, Drum Cleaning/Reclamation, Drum Burning Furnace	3412 Fabricated Metal Products	332 Primary Metal Manufacturing; Fabricated Metal Product Manufacturing
40100223	Organic Solvent Evaporation, Degreasing, Perchloroethylene: Conveyorized Vapor Degreasing	3679 Electronic & Other Electric Equipment	334 Primary Metal Manufacturing; Computer and Electronic Product Manufacturing
40100236	Organic Solvent Evaporation, Degreasing, Entire Unit: with Non-boiling Solvent: Conveyorized Vapor Degreasing	3479 Fabricated Metal Products	332 Primary Metal Manufacturing; Fabricated Metal Product Manufacturing
40100252	Organic Solvent Evaporation, Degreasing, 1,1,1-Trichloroethane (Methyl Chloroform): General Degreasing Units	3469 Fabricated Metal Products	332 Primary Metal Manufacturing; Fabricated Metal Product Manufacturing
40100295	Organic Solvent Evaporation, Degreasing, Other Not Classified: General Degreasing Units	3829 Instruments and Related Products	334 Primary Metal Manufacturing; Computer and Electronic Product Manufacturing
40100296	Organic Solvent Evaporation, Degreasing, Other Not Classified: General Degreasing Units	3812 Instruments and Related Products	334 Primary Metal Manufacturing; Computer and Electronic Product Manufacturing
40400104	Petroleum Liquids Storage (non-Refinery), Bulk Terminals, Gasoline RVP 13: Breathing Loss (250000 Bbl Capacity)-Fixed Roof Tank	5172 Wholesale Trade - Nondurable Goods	422 Wholesale Trade; Wholesale Trade, Nondurable Goods

SCC	SCC Name	SIC	NAICS
40899999	Organic Chemical Transportation, Specific Liquid, Loading Rack	2952 Petroleum and Coal Products	324 Wood Product Manufacturing; Petroleum and Coal Products Manufacturing
49000201	Organic Solvent Evaporation, Waste Solvent Recovery Operations, Storage Tank Vent	3711 Transportation Equipment	336 Primary Metal Manufacturing; Transportation Equipment Manufacturing
49000202	Organic Solvent Evaporation, Waste Solvent Recovery Operations, Condenser Vent	3732 Transportation Equipment	811 Other Services (except Public Administration); Repair and Maintenance
49090011	Organic Solvent Evaporation, Fuel Fired Equipment, Distillate Oil (No. 2): Incinerators	9711 National Security and Intl. Affairs	928 Public Administration; National Security and International Affairs
49099998	Organic Solvent Evaporation, Miscellaneous Volatile Organic Compound Evaporation, Identify the Process and Solvent in Comments	3812 Instruments and Related Products	334 Primary Metal Manufacturing; Computer and Electronic Product Manufacturing
40100103	Organic Solvent Evaporation, Dry Cleaning, Perchloroethylene	7216 Personal Services	812 Other Services (except Public Administration); Personal and Laundry Services
40100104	Organic Solvent Evaporation, Dry Cleaning, Stoddard (Petroleum Solvent) ** (Use 4-10-001-02 or 4-10-002-02)	7216 Personal Services	812 Other Services (except Public Administration); Personal and Laundry Services
40100198	Organic Solvent Evaporation, Dry Cleaning, Other Not Classified	7211 Personal Services	812 Other Services (except Public Administration); Personal and Laundry Services
40100201	Organic Solvent Evaporation, Degreasing, Stoddard (Petroleum Solvent): Open-top Vapor Degreasing	9711 National Security and Intl. Affairs	928 Public Administration; National Security and International Affairs
40100202	Organic Solvent Evaporation, Degreasing, 1,1,1-Trichloroethane (Methyl Chloroform): Open-top Vapor Degreasing	3672 Electronic & Other Electric Equipment	334 Primary Metal Manufacturing; Computer and Electronic Product Manufacturing
40100203	Organic Solvent Evaporation, Degreasing, Perchloroethylene: Open-top Vapor Degreasing	7216 Personal Services	812 Other Services (except Public Administration); Personal and Laundry Services
40100205	Organic Solvent Evaporation, Degreasing, Trichloroethylene: Open-top Vapor Degreasing	3812 Instruments and Related Products	334 Primary Metal Manufacturing; Computer and Electronic Product Manufacturing
40100222	Organic Solvent Evaporation, Degreasing, 1,1,1-Trichloroethane (Methyl Chloroform):Conveyorized Vapor Degreaser	3829 Instruments and Related Products	334 Primary Metal Manufacturing; Computer and Electronic Product Manufacturing

SCC	SCC Name	SIC	NAICS
40400202	Petroleum Liquids Storage (non-Refinery), Bulk Plants, Gasoline RVP 10: Breathing Loss (67000 Bbl Capacity) - Fixed Roof Tank	5171 Wholesale Trade - Nondurable Goods	422 Wholesale Trade; Wholesale Trade, Nondurable Goods
40400205	Petroleum Liquids Storage (non-Refinery), Bulk Plants, Gasoline RVP 10: Working Loss (67000 Bbl. Capacity) - Fixed Roof Tank	5171 Wholesale Trade - Nondurable Goods	422 Wholesale Trade; Wholesale Trade, Nondurable Goods
40400210	Petroleum Liquids Storage (non-Refinery), Bulk Plants, Gasoline RVP 13/10/7: Withdrawal Loss (67000 Bbl Cap.) - Float Rf Tnk	5171 Wholesale Trade - Nondurable Goods	422 Wholesale Trade; Wholesale Trade, Nondurable Goods
40400212	Petroleum Liquids Storage (non-Refinery), Bulk Plants, Gasoline RVP 10: Filling Loss (10500 Bbl Cap.) - Variable Vapor Space	5171 Wholesale Trade - Nondurable Goods	422 Wholesale Trade; Wholesale Trade, Nondurable Goods
30501199	Mineral Products, Concrete Batching, Other Not Classified	1422 Nonmetallic Minerals, Except Fuels	212 Mining; Mining (except Oil and Gas)
30501402	Mineral Products, Glass Manufacture, Container Glass: Melting Furnace	2819 Chemicals and Allied Products	331 Primary Metal Manufacturing; Primary Metal Manufacturing
30501403	Mineral Products, Glass Manufacture, Flat Glass: Melting Furnace	3221 Stone, Clay, and Glass Products	327 Wood Product Manufacturing; Nonmetallic Mineral Product Manufacturing
30501406	Mineral Products, Glass Manufacture, Container Glass: Forming/Finishing	3221 Stone, Clay, and Glass Products	327 Wood Product Manufacturing; Nonmetallic Mineral Product Manufacturing
30501413	Mineral Products, Glass Manufacture, Cullet: Crushing/Grinding	3221 Stone, Clay, and Glass Products	327 Wood Product Manufacturing; Nonmetallic Mineral Product Manufacturing
30501415	Mineral Products, Glass Manufacture, Glass Etching with Hydrofluoric Acid Solution	3221 Stone, Clay, and Glass Products	327 Wood Product Manufacturing; Nonmetallic Mineral Product Manufacturing
30501501	Mineral Products, Gypsum Manufacture, Rotary Ore Dryer	3275 Stone, Clay, and Glass Products	327 Wood Product Manufacturing; Nonmetallic Mineral Product Manufacturing
30501502	Mineral Products, Gypsum Manufacture, Primary Grinder/Roller Mills	3275 Stone, Clay, and Glass Products	327 Wood Product Manufacturing; Nonmetallic Mineral Product Manufacturing
30501504	Mineral Products, Gypsum Manufacture, Conveying	3275 Stone, Clay, and Glass Products	327 Wood Product Manufacturing; Nonmetallic Mineral Product Manufacturing

SCC	SCC Name	SIC	NAICS
30501508	Mineral Products, Gypsum Manufacture, Stockpile: Gypsum Ore	3275 Stone, Clay, and Glass Products	327 Wood Product Manufacturing; Nonmetallic Mineral Product Manufacturing
30501509	Mineral Products, Gypsum Manufacture, Storage Bins: Gypsum Ore	3275 Stone, Clay, and Glass Products	327 Wood Product Manufacturing; Nonmetallic Mineral Product Manufacturing
30501518	Mineral Products, Gypsum Manufacture, Mixers/Conveyors	3275 Stone, Clay, and Glass Products	327 Wood Product Manufacturing; Nonmetallic Mineral Product Manufacturing
30501520	Mineral Products, Gypsum Manufacture, Drying Kiln	3275 Stone, Clay, and Glass Products	327 Wood Product Manufacturing; Nonmetallic Mineral Product Manufacturing
30501521	Mineral Products, Gypsum Manufacture, End Sawing (8 Ft.)	3275 Stone, Clay, and Glass Products	327 Wood Product Manufacturing; Nonmetallic Mineral Product Manufacturing
30510298	Mineral Products, Bulk Materials Storage Bins, Mineral: Specify in Comments	2891 Chemicals and Allied Products	325 Wood Product Manufacturing; Chemical Manufacturing
30510403	Mineral Products, Bulk Materials Unloading Operation, Coal	3312 Primary Metal Industries	324 Wood Product Manufacturing; Petroleum and Coal Products Manufacturing
30599999	Mineral Products, Other Not Defined, Specify in Comments Field	3996 Miscellaneous Manufacturing Industries	326 Wood Product Manufacturing; Plastics and Rubber Products Manufacturing
30600103	Petroleum Industry, Process Heaters, Oil-fired	2911 Petroleum and Coal Products	324 Wood Product Manufacturing; Petroleum and Coal Products Manufacturing
30600104	Petroleum Industry, Process Heaters, Gas-fired	2911 Petroleum and Coal Products	324 Wood Product Manufacturing; Petroleum and Coal Products Manufacturing
30600201	Petroleum Industry, Catalytic Cracking Units, Fluid Catalytic Cracking Unit	2911 Petroleum and Coal Products	324 Wood Product Manufacturing; Petroleum and Coal Products Manufacturing
30600504	Petroleum Industry, Wastewater Treatment, Process Drains and Wastewater Separators	2911 Petroleum and Coal Products	324 Wood Product Manufacturing; Petroleum and Coal Products Manufacturing
30600801	Petroleum Industry, Fugitive Emissions, Pipeline Valves and Flanges	2911 Petroleum and Coal Products	324 Wood Product Manufacturing; Petroleum and Coal Products Manufacturing

SCC	SCC Name	SIC	NAICS
30600802	Petroleum Industry, Fugitive Emissions, Vessel Relief Valves	2911 Petroleum and Coal Products	324 Wood Product Manufacturing; Petroleum and Coal Products Manufacturing
30600803	Petroleum Industry, Fugitive Emissions, Pump Seals w/o Controls	2911 Petroleum and Coal Products	324 Wood Product Manufacturing; Petroleum and Coal Products Manufacturing
30600804	Petroleum Industry, Fugitive Emissions, Compressor Seals	2911 Petroleum and Coal Products	324 Wood Product Manufacturing; Petroleum and Coal Products Manufacturing
30600805	Petroleum Industry, Fugitive Emissions, Miscellaneous: Sampling/Non-Asphalt Blowing/Purging/etc.	2911 Petroleum and Coal Products	324 Wood Product Manufacturing; Petroleum and Coal Products Manufacturing
40200998	Surface Coating Operations, Thinning Solvents - General, General: Specify in Comments	3444 Fabricated Metal Products	332 Primary Metal Manufacturing; Fabricated Metal Product Manufacturing
40201001	Surface Coating Operations, Coating Oven Heater, Natural Gas	3669 Electronic & Other Electric Equipment	334 Primary Metal Manufacturing; Computer and Electronic Product Manufacturing
40201004	Surface Coating Operations, Coating Oven Heater, Liquified Petroleum Gas (LPG)	9223 Justice, Public Order, and Safety	922 Public Administration; Justice, Public Order, and Safety Activities
40201101	Surface Coating Operations, Fabric Coating/Printing, Coating Operation (Also See Specific Coating Method Codes 4-02-04X)	3999 Miscellaneous Manufacturing Industries	337 Primary Metal Manufacturing; Furniture and Related Product Manufacturing
40201301	Surface Coating Operations, Paper Coating, Coating Operation	3812 Instruments and Related Products	334 Primary Metal Manufacturing; Computer and Electronic Product Manufacturing
40201432	Surface Coating Operations, Large Appliances, Prime Air Spray	3589 Industrial Machinery and Equipment	333 Primary Metal Manufacturing; Machinery Manufacturing
40201599	Surface Coating Operations, Magnet Wire Surface Coating, Other Not Classified	3669 Electronic & Other Electric Equipment	334 Primary Metal Manufacturing; Computer and Electronic Product Manufacturing
40201605	Surface Coating Operations, Automobiles and Light Trucks, Equipment Cleanup	3711 Transportation Equipment	336 Primary Metal Manufacturing; Transportation Equipment Manufacturing
40201620	Surface Coating Operations, Automobiles and Light Trucks, Repair Topcoat Application Area	9711 National Security and Intl. Affairs	928 Public Administration; National Security and International Affairs

SCC	SCC Name	SIC	NAICS
40201621	Surface Coating Operations, Automobiles and Light Trucks, Prime Coating: Solvent-borne - Automobiles	7549 Auto Repair, Services, and Parking	488 Air Transportation; Support Activities for Transportation
40201625	Surface Coating Operations, Automobiles and Light Trucks, Topcoat: Solvent-borne - Automobiles	5511 Automotive Dealers & Service Stations	441 Motor Vehicle and Parts Dealers; Motor Vehicle and Parts Dealers
40201628	Surface Coating Operations, Automobiles and Light Trucks, Prime Coating: Electro-deposition - Light Trucks	3711 Transportation Equipment	336 Primary Metal Manufacturing; Transportation Equipment Manufacturing
40201631	Surface Coating Operations, Automobiles and Light Trucks, Topcoat: Solvent-borne - Light Trucks	3711 Transportation Equipment	336 Primary Metal Manufacturing; Transportation Equipment Manufacturing
40201632	Surface Coating Operations, Automobiles and Light Trucks, Topcoat: Water-borne - Light Trucks	5411 Food Stores	452 Sporting Goods, Hobby, Book, and Music Stores; General Merchandise Stores
40201699	Surface Coating Operations, Automobiles and Light Trucks, Other Not Classified	3711 Transportation Equipment	336 Primary Metal Manufacturing; Transportation Equipment Manufacturing
40201724	Surface Coating Operations, Metal Can Coating, Sheet Base Coating (Exterior)	3411 Fabricated Metal Products	332 Primary Metal Manufacturing; Fabricated Metal Product Manufacturing
40201726	Surface Coating Operations, Metal Can Coating, End Sealing Compound (Also See 4-02-017-36 & -37)	3411 Fabricated Metal Products	332 Primary Metal Manufacturing; Fabricated Metal Product Manufacturing
40201727	Surface Coating Operations, Metal Can Coating, Lithography	3411 Fabricated Metal Products	332 Primary Metal Manufacturing; Fabricated Metal Product Manufacturing
40201731	Surface Coating Operations, Metal Can Coating, Three-piece Can Sheet Base Coating	3411 Fabricated Metal Products	332 Primary Metal Manufacturing; Fabricated Metal Product Manufacturing
40201732	Surface Coating Operations, Metal Can Coating, Three-piece Can Sheet Lithographic Coating Line	3411 Fabricated Metal Products	332 Primary Metal Manufacturing; Fabricated Metal Product Manufacturing
40201799	Surface Coating Operations, Metal Can Coating, Other Not Classified	3411 Fabricated Metal Products	332 Primary Metal Manufacturing; Fabricated Metal Product Manufacturing
40201806	Surface Coating Operations, Metal Coil Coating, Finish Coating	3479 Fabricated Metal Products	332 Primary Metal Manufacturing; Fabricated Metal Product Manufacturing

SCC	SCC Name	SIC	NAICS
40201901	Surface Coating Operations, Wood Furniture Surface Coating, Coating Operation	2511 Furniture and Fixtures	337 Primary Metal Manufacturing; Furniture and Related Product Manufacturing
40201999	Surface Coating Operations, Wood Furniture Surface Coating, Other Not Classified	2511 Furniture and Fixtures	337 Primary Metal Manufacturing; Furniture and Related Product Manufacturing
40202001	Surface Coating Operations, Metal Furniture Operations, Coating Operation	9223 Justice, Public Order, and Safety	922 Public Administration; Justice, Public Order, and Safety Activities
40202101	Surface Coating Operations, Flatwood Products, Base Coat	2434 Lumber and Wood Products	337 Primary Metal Manufacturing; Furniture and Related Product Manufacturing
40202105	Surface Coating Operations, Flatwood Products, Equipment Cleanup	2434 Lumber and Wood Products	337 Primary Metal Manufacturing; Furniture and Related Product Manufacturing
40202106	Surface Coating Operations, Flatwood Products, Topcoat	2434 Lumber and Wood Products	337 Primary Metal Manufacturing; Furniture and Related Product Manufacturing
40202108	Surface Coating Operations, Flatwood Products, Sealer	2434 Lumber and Wood Products	337 Primary Metal Manufacturing; Furniture and Related Product Manufacturing
40202201	Surface Coating Operations, Plastic Parts, Coating Operation	3089 Rubber and Misc. Plastics Products	337 Primary Metal Manufacturing; Furniture and Related Product Manufacturing
40202399	Surface Coating Operations, Large Ships, Other Not Classified	3731 Transportation Equipment	336 Primary Metal Manufacturing; Transportation Equipment Manufacturing
30601101	Petroleum Industry, Asphalt Blowing, General	2952 Petroleum and Coal Products	324 Wood Product Manufacturing; Petroleum and Coal Products Manufacturing
30700101	Pulp and Paper and Wood Products, Sulfate (Kraft) Pulping, Digester Relief and Blow Tank	2621 Paper and Allied Products	322 Wood Product Manufacturing; Paper Manufacturing
30700102	Pulp and Paper and Wood Products, Sulfate (Kraft) Pulping, Washer/Screens	2621 Paper and Allied Products	322 Wood Product Manufacturing; Paper Manufacturing
30700103	Pulp and Paper and Wood Products, Sulfate (Kraft) Pulping, Multi-effect Evaporator	2621 Paper and Allied Products	322 Wood Product Manufacturing; Paper Manufacturing

SCC	SCC Name	SIC	NAICS
30700104	Pulp and Paper and Wood Products, Sulfate (Kraft) Pulping, Recovery Furnace/Direct Contact Evaporator	2621 Paper and Allied Products	322 Wood Product Manufacturing; Paper Manufacturing
30700105	Pulp and Paper and Wood Products, Sulfate (Kraft) Pulping, Smelt Dissolving Tank	2621 Paper and Allied Products	322 Wood Product Manufacturing; Paper Manufacturing
30700106	Pulp and Paper and Wood Products, Sulfate (Kraft) Pulping, Lime Kiln	2675 Paper and Allied Products	322 Wood Product Manufacturing; Paper Manufacturing
30700199	Pulp and Paper and Wood Products, Sulfate (Kraft) Pulping, Other Not Classified	2621 Paper and Allied Products	322 Wood Product Manufacturing; Paper Manufacturing
30700401	Pulp and Paper and Wood Products, Pulpboard Manufacture, Paperboard: General	2675 Paper and Allied Products	322 Wood Product Manufacturing; Paper Manufacturing
30700501	Pulp and Paper and Wood Products, Wood Pressure Treating, Creosote	2491 Lumber and Wood Products	321 Wood Product Manufacturing; Wood Product Manufacturing
30700599	Pulp and Paper and Wood Products, Wood Pressure Treating, Other Not Classified	2491 Lumber and Wood Products	321 Wood Product Manufacturing; Wood Product Manufacturing
30700701	Pulp and Paper and Wood Products, Plywood Operations, General: Not Classified **	2436 Lumber and Wood Products	321 Wood Product Manufacturing; Wood Product Manufacturing
30700702	Pulp and Paper and Wood Products, Plywood Operations, Sanding Operations	2499 Lumber and Wood Products	339 Primary Metal Manufacturing; Miscellaneous Manufacturing
30700703	Pulp and Paper and Wood Products, Plywood Operations, Particleboard Drying(See 3-07-006 For More Detailed Particleboard SCC)	3083 Rubber and Misc. Plastics Products	326 Wood Product Manufacturing; Plastics and Rubber Products Manufacturing
30700706	Pulp and Paper and Wood Products, Plywood Operations, Hardboard: Predryer	2436 Lumber and Wood Products	321 Wood Product Manufacturing; Wood Product Manufacturing
30700707	Pulp and Paper and Wood Products, Plywood Operations, Hardboard: Pressing	2493 Lumber and Wood Products	321 Wood Product Manufacturing; Wood Product Manufacturing
30700798	Pulp and Paper and Wood Products, Plywood Operations, Other Not Classified	2491 Lumber and Wood Products	321 Wood Product Manufacturing; Wood Product Manufacturing

SCC	SCC Name	SIC	NAICS
30700799	Pulp and Paper and Wood Products, Plywood Operations, Other Not Classified	2436 Lumber and Wood Products	321 Wood Product Manufacturing; Wood Product Manufacturing
30700897	Pulp and Paper and Wood Products, Sawmill Operations, Other Not Classified	2426 Lumber and Wood Products	337 Primary Metal Manufacturing; Furniture and Related Product Manufacturing
30700898	Pulp and Paper and Wood Products, Sawmill Operations, Other Not Classified	2426 Lumber and Wood Products	337 Primary Metal Manufacturing; Furniture and Related Product Manufacturing
30700899	Pulp and Paper and Wood Products, Sawmill Operations, Other Not Classified	2426 Lumber and Wood Products	337 Primary Metal Manufacturing; Furniture and Related Product Manufacturing
30702099	Pulp and Paper and Wood Products, Furniture Manufacture, Other Not Classified	2511 Furniture and Fixtures	337 Primary Metal Manufacturing; Furniture and Related Product Manufacturing
30703001	Pulp and Paper and Wood Products, Miscellaneous Wood Working Operations, Wood Waste Storage Bin Vent	2499 Lumber and Wood Products	339 Primary Metal Manufacturing; Miscellaneous Manufacturing
30703002	Pulp and Paper and Wood Products, Miscellaneous Wood Working Operations, Wood Waste Storage Bin Loadout	2499 Lumber and Wood Products	339 Primary Metal Manufacturing; Miscellaneous Manufacturing
30703097	Pulp and Paper and Wood Products, Miscellaneous Wood Working Operations, Sanding/Planning Operations: Specify	2431 Lumber and Wood Products	321 Wood Product Manufacturing; Wood Product Manufacturing
30703099	Pulp and Paper and Wood Products, Miscellaneous Wood Working Operations, Sanding/Planning Operations: Specify	2426 Lumber and Wood Products	337 Primary Metal Manufacturing; Furniture and Related Product Manufacturing
30790003	Pulp and Paper and Wood Products, Fuel Fired Equipment, Natural Gas: Process Heaters	2621 Paper and Allied Products	322 Wood Product Manufacturing; Paper Manufacturing
30800101	Rubber and Miscellaneous Plastics Products, Tire Manufacture, Undertread and Sidewall Cementing	3011 Rubber and Misc. Plastics Products	326 Wood Product Manufacturing; Plastics and Rubber Products Manufacturing
30800102	Rubber and Miscellaneous Plastics Products, Tire Manufacture, Bead Dipping	3011 Rubber and Misc. Plastics Products	326 Wood Product Manufacturing; Plastics and Rubber Products Manufacturing
30800104	Rubber and Miscellaneous Plastics Products, Tire Manufacture, Tire Building	3011 Rubber and Misc. Plastics Products	326 Wood Product Manufacturing; Plastics and Rubber Products Manufacturing

SCC	SCC Name	SIC	NAICS
30800105	Rubber and Miscellaneous Plastics Products, Tire Manufacture, Tread End Cementing	3011 Rubber and Misc. Plastics Products	326 Wood Product Manufacturing; Plastics and Rubber Products Manufacturing
30800106	Rubber and Miscellaneous Plastics Products, Tire Manufacture, Green Tire Spraying	3011 Rubber and Misc. Plastics Products	326 Wood Product Manufacturing; Plastics and Rubber Products Manufacturing
30800107	Rubber and Miscellaneous Plastics Products, Tire Manufacture, Tire Curing	3011 Rubber and Misc. Plastics Products	326 Wood Product Manufacturing; Plastics and Rubber Products Manufacturing
30800199	Rubber and Miscellaneous Plastics Products, Tire Manufacture, Other Not Classified	7534 Auto Repair, Services, and Parking	326 Wood Product Manufacturing; Plastics and Rubber Products Manufacturing
30800501	Rubber and Miscellaneous Plastics Products, Tire Retreading, Tire Buffing Machines	7534 Auto Repair, Services, and Parking	326 Wood Product Manufacturing; Plastics and Rubber Products Manufacturing
30800699	Rubber and Miscellaneous Plastics Products, Other Fabricated Plastics, Other Not Classified	3082 Rubber and Misc. Plastics Products	326 Wood Product Manufacturing; Plastics and Rubber Products Manufacturing
30800701	Rubber and Miscellaneous Plastics Products, Fiberglass Resin Products, Plastics Machining: Drilling/Sanding/Sawing/etc.	3083 Rubber and Misc. Plastics Products	326 Wood Product Manufacturing; Plastics and Rubber Products Manufacturing
40400105	Petroleum Liquids Storage (non-Refinery), Bulk Terminals, Gasoline RVP 10: Breathing Loss (250000 Bbl Capacity)-Fixed Roof Tank	5171 Wholesale Trade - Nondurable Goods	422 Wholesale Trade; Wholesale Trade, Nondurable Goods
40400108	Petroleum Liquids Storage (non-Refinery), Bulk Terminals, Gasoline RVP 10: Working Loss (Diameter Independent) - Fixed Roof Tank	5171 Wholesale Trade - Nondurable Goods	422 Wholesale Trade; Wholesale Trade, Nondurable Goods
40400109	Petroleum Liquids Storage (non-Refinery), Bulk Terminals, Gasoline RVP 7: Working Loss (Diameter Independent) - Fixed Roof Tank	5171 Wholesale Trade - Nondurable Goods	422 Wholesale Trade; Wholesale Trade, Nondurable Goods
40400110	Petroleum Liquids Storage (non-Refinery), Bulk Terminals, Gasoline RVP 13: Standing Loss (67000 Bbl Capacity)-Floating Roof Tank	5171 Wholesale Trade - Nondurable Goods	422 Wholesale Trade; Wholesale Trade, Nondurable Goods
40400111	Petroleum Liquids Storage (non-Refinery), Bulk Terminals, Gasoline RVP 10: Standing Loss (67000 Bbl Capacity)-Floating Roof Tank	5171 Wholesale Trade - Nondurable Goods	422 Wholesale Trade; Wholesale Trade, Nondurable Goods
40400113	Petroleum Liquids Storage (non-Refinery), Bulk Terminals, Gasoline RVP 13: Standing Loss (250000 Bbl Cap.) - Floating Roof Tank	5171 Wholesale Trade - Nondurable Goods	422 Wholesale Trade; Wholesale Trade, Nondurable Goods

SCC	SCC Name	SIC	NAICS
40400114	Petroleum Liquids Storage (non-Refinery), Bulk Terminals, Gasoline RVP 10: Standing Loss (250000 Bbl Cap.) - Floating Roof Tank	5171 Wholesale Trade - Nondurable Goods	422 Wholesale Trade; Wholesale Trade, Nondurable Goods
40400301	Petroleum Liquids Storage (non-Refinery), Oil and Gas Field Storage and Working Tanks, Fixed Roof Tank: Breathing Loss	5171 Wholesale Trade - Nondurable Goods	422 Wholesale Trade; Wholesale Trade, Nondurable Goods
40400302	Petroleum Liquids Storage (non-Refinery), Oil and Gas Field Storage and Working Tanks, Fixed Roof Tank: Working Loss	5171 Wholesale Trade - Nondurable Goods	422 Wholesale Trade; Wholesale Trade, Nondurable Goods
40400402	Petroleum Liquids Storage (non-Refinery), Petroleum Products - Underground Tanks, Gasoline RVP 13: Working Loss	1611 Heavy Construction, Ex. Building	234 Construction; Heavy Construction
40400403	Petroleum Liquids Storage (non-Refinery), Petroleum Products - Underground Tanks, Gasoline RVP 10: Breathing Loss	1422 Nonmetallic Minerals, Except Fuels	212 Mining; Mining (except Oil and Gas)
40400404	Petroleum Liquids Storage (non-Refinery), Petroleum Products - Underground Tanks, Gasoline RVP 10: Working Loss	2711 Printing and Publishing	511 Information; Publishing Industries
40400410	Petroleum Liquids Storage (non-Refinery), Petroleum Products - Underground Tanks, Jet Naphtha (JP-4): Working Loss	5171 Wholesale Trade - Nondurable Goods	422 Wholesale Trade; Wholesale Trade, Nondurable Goods
40400497	Petroleum Liquids Storage (non-Refinery), Petroleum Products - Underground Tanks, Specify Liquid: Breathing Loss	9711 National Security and Intl. Affairs	928 Public Administration; National Security and International Affairs
40400498	Petroleum Liquids Storage (non-Refinery), Petroleum Products - Underground Tanks, Specify Liquid: Working Loss	2891 Chemicals and Allied Products	325 Wood Product Manufacturing; Chemical Manufacturing
40500101	Printing/Publishing, Drying, Dryer	2759 Printing and Publishing	323 Wood Product Manufacturing; Printing and Related Support Activities
40500199	Printing/Publishing, Drying, Dryer	2759 Printing and Publishing	323 Wood Product Manufacturing; Printing and Related Support Activities
40500201	Printing/Publishing, General, Letter Press: 2751	2759 Printing and Publishing	323 Wood Product Manufacturing; Printing and Related Support Activities
40500301	Printing/Publishing, General, Printing: Flexographic	2759 Printing and Publishing	323 Wood Product Manufacturing; Printing and Related Support Activities

SCC	SCC Name	SIC	NAICS
40500305	Printing/Publishing, General, Ink Thinning Solvent (Isopropyl Alcohol)	2759 Printing and Publishing	323 Wood Product Manufacturing; Printing and Related Support Activities
40500307	Printing/Publishing, General, Ink Thinning Solvent (Naphtha)	2759 Printing and Publishing	323 Wood Product Manufacturing; Printing and Related Support Activities
40500312	Printing/Publishing, General, Printing: Flexographic	2752 Printing and Publishing	323 Wood Product Manufacturing; Printing and Related Support Activities
40500401	Printing/Publishing, General, Lithographic: 2752	2759 Printing and Publishing	323 Wood Product Manufacturing; Printing and Related Support Activities
40500411	Printing/Publishing, General, Lithographic: 2752	9711 National Security and Intl. Affairs	928 Public Administration; National Security and International Affairs
40500412	Printing/Publishing, General, Lithographic: 2752	2711 Printing and Publishing	511 Information; Publishing Industries
40500501	Printing/Publishing, General, Gravure: 2754	2759 Printing and Publishing	323 Wood Product Manufacturing; Printing and Related Support Activities
40500512	Printing/Publishing, General, Gravure: 2754	2731 Printing and Publishing	512 Information; Motion Picture and Sound Recording Industries
40500513	Printing/Publishing, General, Gravure: 2754	2754 Printing and Publishing	323 Wood Product Manufacturing; Printing and Related Support Activities
40500598	Printing/Publishing, General, Ink Thinning Solvent: Other Not Specified	2752 Printing and Publishing	323 Wood Product Manufacturing; Printing and Related Support Activities
40500599	Printing/Publishing, General, Ink Thinning Solvent: Other Not Specified	2752 Printing and Publishing	323 Wood Product Manufacturing; Printing and Related Support Activities
40500701	Printing/Publishing, General, Solvent Storage	2754 Printing and Publishing	323 Wood Product Manufacturing; Printing and Related Support Activities
40500812	Printing/Publishing, General, Screen Printing	3829 Instruments and Related Products	334 Primary Metal Manufacturing; Computer and Electronic Product Manufacturing

SCC	SCC Name	SIC	NAICS
40588801	Printing/Publishing, Fugitive Emissions, Specify in Comments Field	2759 Printing and Publishing	323 Wood Product Manufacturing; Printing and Related Support Activities
40588802	Printing/Publishing, Fugitive Emissions, Specify in Comments Field	2759 Printing and Publishing	323 Wood Product Manufacturing; Printing and Related Support Activities
40100297	Organic Solvent Evaporation, Degreasing, Other Not Classified: Open-top Vapor Degreasing	3674 Electronic & Other Electric Equipment	334 Primary Metal Manufacturing; Computer and Electronic Product Manufacturing
40100298	Organic Solvent Evaporation, Degreasing, Other Not Classified: Conveyorized Vapor Degreasing	3829 Instruments and Related Products	334 Primary Metal Manufacturing; Computer and Electronic Product Manufacturing
40100299	Organic Solvent Evaporation, Degreasing, Other Not Classified: Open-top Vapor Degreasing	5065 Wholesale Trade - Durable Goods	421 Wholesale Trade; Wholesale Trade, Durable Goods
40100302	Organic Solvent Evaporation, Cold Solvent Cleaning/Stripping, Methylene Chloride	3672 Electronic & Other Electric Equipment	334 Primary Metal Manufacturing; Computer and Electronic Product Manufacturing
40100305	Organic Solvent Evaporation, Cold Solvent Cleaning/Stripping, 1,1,1-Trichloroethane (Methyl Chloroform)	3672 Electronic & Other Electric Equipment	334 Primary Metal Manufacturing; Computer and Electronic Product Manufacturing
40100335	Organic Solvent Evaporation, Cold Solvent Cleaning/Stripping, Entire Unit	3743 Transportation Equipment	333 Primary Metal Manufacturing; Machinery Manufacturing
40100336	Organic Solvent Evaporation, Cold Solvent Cleaning/Stripping, Degreaser: Entire Unit	7542 Auto Repair, Services, and Parking	811 Other Services (except Public Administration); Repair and Maintenance
40100398	Organic Solvent Evaporation, Cold Solvent Cleaning/Stripping, Other Not Classified	7532 Auto Repair, Services, and Parking	811 Other Services (except Public Administration); Repair and Maintenance
40100399	Organic Solvent Evaporation, Cold Solvent Cleaning/Stripping, Other Not Classified	9711 National Security and Intl. Affairs	928 Public Administration; National Security and International Affairs
40188801	Organic Solvent Evaporation, Fugitive Emissions, Specify in Comments Field	9711 National Security and Intl. Affairs	928 Public Administration; National Security and International Affairs
40188898	Organic Solvent Evaporation, Fugitive Emissions, Specify in Comments Field	5169 Wholesale Trade - Nondurable Goods	422 Wholesale Trade; Wholesale Trade, Nondurable Goods

SCC	SCC Name	SIC	NAICS
40200101	Surface Coating Operations, Surface Coating Application - General, Paint: Solvent-base	1422 Nonmetallic Minerals, Except Fuels	212 Mining; Mining (except Oil and Gas)
40200110	Surface Coating Operations, Surface Coating Application - General, Paint: Solvent-base	2431 Lumber and Wood Products	321 Wood Product Manufacturing; Wood Product Manufacturing
40200201	Surface Coating Operations, Surface Coating Application - General, Paint: Water-base	3089 Rubber and Misc. Plastics Products	337 Primary Metal Manufacturing; Furniture and Related Product Manufacturing
40200210	Surface Coating Operations, Surface Coating Application - General, Paint: Water-base	3731 Transportation Equipment	336 Primary Metal Manufacturing; Transportation Equipment Manufacturing
40200310	Surface Coating Operations, Surface Coating Application - General, Varnish/Shellac	3479 Fabricated Metal Products	332 Primary Metal Manufacturing; Fabricated Metal Product Manufacturing
40200401	Surface Coating Operations, Surface Coating Application - General, Lacquer	9711 National Security and Intl. Affairs	928 Public Administration; National Security and International Affairs
40200410	Surface Coating Operations, Surface Coating Application - General, Lacquer	3931 Miscellaneous Manufacturing Industries	339 Primary Metal Manufacturing; Miscellaneous Manufacturing
40200501	Surface Coating Operations, Surface Coating Application - General, Enamel	3443 Fabricated Metal Products	333 Primary Metal Manufacturing; Machinery Manufacturing
40200510	Surface Coating Operations, Surface Coating Application - General, Enamel	3674 Electronic & Other Electric Equipment	334 Primary Metal Manufacturing; Computer and Electronic Product Manufacturing
40200601	Surface Coating Operations, Surface Coating Application - General, Primer	3993 Miscellaneous Manufacturing Industries	339 Primary Metal Manufacturing; Miscellaneous Manufacturing
40200610	Surface Coating Operations, Surface Coating Application - General, Primer	3812 Instruments and Related Products	334 Primary Metal Manufacturing; Computer and Electronic Product Manufacturing
40200701	Surface Coating Operations, Surface Coating Application - General, Adhesive Application	3732 Transportation Equipment	811 Other Services (except Public Administration); Repair and Maintenance
40200706	Surface Coating Operations, Surface Coating Application - General, Adhesive: Solvent Mixing	2891 Chemicals and Allied Products	325 Wood Product Manufacturing; Chemical Manufacturing

SCC	SCC Name	SIC	NAICS
40200710	Surface Coating Operations, Surface Coating Application - General, Adhesive: General	3993 Miscellaneous Manufacturing Industries	339 Primary Metal Manufacturing; Miscellaneous Manufacturing
40200801	Surface Coating Operations, Coating Oven - General, General	3569 Industrial Machinery and Equipment	314 Food Manufacturing; Textile Product Mills
40200802	Surface Coating Operations, Coating Oven - General, Dried < 175F **	5085 Wholesale Trade - Durable Goods	421 Wholesale Trade; Wholesale Trade, Durable Goods
40200810	Surface Coating Operations, Coating Oven - General, General	9711 National Security and Intl. Affairs	928 Public Administration; National Security and International Affairs
40200898	Surface Coating Operations, Coating Oven - General, General	3669 Electronic & Other Electric Equipment	334 Primary Metal Manufacturing; Computer and Electronic Product Manufacturing
40200901	Surface Coating Operations, Thinning Solvents - General, General: Specify in Comments	2435 Lumber and Wood Products	321 Wood Product Manufacturing; Wood Product Manufacturing
40200911	Surface Coating Operations, Thinning Solvents - General, Gasoline	3011 Rubber and Misc. Plastics Products	326 Wood Product Manufacturing; Plastics and Rubber Products Manufacturing
40200920	Surface Coating Operations, Thinning Solvents - General, Mineral Spirits	3612 Electronic & Other Electric Equipment	335 Primary Metal Manufacturing; Electrical Equipment, Appliance, and Component Manufacturing
40200921	Surface Coating Operations, Thinning Solvents - General, Naphtha	3053 Rubber and Misc. Plastics Products	339 Primary Metal Manufacturing; Miscellaneous Manufacturing
40200922	Surface Coating Operations, Thinning Solvents - General, Toluene	3479 Fabricated Metal Products	332 Primary Metal Manufacturing; Fabricated Metal Product Manufacturing
40200923	Surface Coating Operations, Thinning Solvents - General, Varsol	2621 Paper and Allied Products	322 Wood Product Manufacturing; Paper Manufacturing
40200924	Surface Coating Operations, Thinning Solvents - General, Xylene	3612 Electronic & Other Electric Equipment	335 Primary Metal Manufacturing; Electrical Equipment, Appliance, and Component Manufacturing
40202405	Surface Coating Operations, Large Aircraft, Equipment Cleanup	3728 Transportation Equipment	541 Professional, Scientific, and Technical Services; Professional, Scientific, and Technical Services

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40202406	Surface Coating Operations, Large Aircraft, Topcoat Operation	3728 Transportation Equipment	541 Professional, Scientific, and Technical Services; Professional, Scientific, and Technical Services
40202501	Surface Coating Operations, Miscellaneous Metal Parts, Coating Operation	3496 Fabricated Metal Products	332 Primary Metal Manufacturing; Fabricated Metal Product Manufacturing
40202502	Surface Coating Operations, Miscellaneous Metal Parts, Cleaning/Pretreatment	3812 Instruments and Related Products	334 Primary Metal Manufacturing; Computer and Electronic Product Manufacturing
40202537	Surface Coating Operations, Miscellaneous Metal Parts, Manual Two Coat, Spray and Air Dry	3441 Fabricated Metal Products	332 Primary Metal Manufacturing; Fabricated Metal Product Manufacturing
40202599	Surface Coating Operations, Miscellaneous Metal Parts, Other Not Classified	9711 National Security and Intl. Affairs	928 Public Administration; National Security and International Affairs
40202601	Surface Coating Operations, Steel Drums, Coating Operation	5085 Wholesale Trade - Durable Goods	421 Wholesale Trade; Wholesale Trade, Durable Goods
40202606	Surface Coating Operations, Steel Drums, Interior Coating	5085 Wholesale Trade - Durable Goods	421 Wholesale Trade; Wholesale Trade, Durable Goods
40288801	Surface Coating Operations, Fugitive Emissions, Specify in Comments Field	3812 Instruments and Related Products	334 Primary Metal Manufacturing; Computer and Electronic Product Manufacturing
40299995	Surface Coating Operations, Miscellaneous, Specify in Comments Field	3669 Electronic & Other Electric Equipment	334 Primary Metal Manufacturing; Computer and Electronic Product Manufacturing
40299998	Surface Coating Operations, Miscellaneous, Specify in Comments Field	3669 Electronic & Other Electric Equipment	334 Primary Metal Manufacturing; Computer and Electronic Product Manufacturing
40301008	Petroleum Product Storage at Refineries, Fixed Roof Tanks (Varying Sizes), Gasoline RVP 10: Working Loss (Tank Diameter Independent)	5171 Wholesale Trade - Nondurable Goods	422 Wholesale Trade; Wholesale Trade, Nondurable Goods
40301011	Petroleum Product Storage at Refineries, Fixed Roof Tanks (Varying Sizes), Crude Oil RVP 5: Breathing Loss (250000 Bbl. Tank Size)	5171 Wholesale Trade - Nondurable Goods	422 Wholesale Trade; Wholesale Trade, Nondurable Goods
40301016	Petroleum Product Storage at Refineries, Fixed Roof Tanks (Varying Sizes), Jet Kerosene: Breathing Loss (67000 Bbl. Tank Size)	5171 Wholesale Trade - Nondurable Goods	422 Wholesale Trade; Wholesale Trade, Nondurable Goods

SCC	SCC Name	SIC	NAICS
40301018	Petroleum Product Storage at Refineries, Fixed Roof Tanks (Varying Sizes), Jet Kerosene: Working Loss (Tank Diameter Independent)	5171 Wholesale Trade - Nondurable Goods	422 Wholesale Trade; Wholesale Trade, Nondurable Goods
40301019	Petroleum Product Storage at Refineries, Fixed Roof Tanks (Varying Sizes), Distillate Fuel #2: Breathing Loss (67000 Bbl. Tank Size)	5171 Wholesale Trade - Nondurable Goods	422 Wholesale Trade; Wholesale Trade, Nondurable Goods
40301021	Petroleum Product Storage at Refineries, Fixed Roof Tanks (Varying Sizes), Distillate Fuel #2: Working Loss (Tank Diameter Independent)	5171 Wholesale Trade - Nondurable Goods	422 Wholesale Trade; Wholesale Trade, Nondurable Goods
40301097	Petroleum Product Storage at Refineries, Fixed Roof Tanks (Varying Sizes), Specify Liquid: Breathing Loss (67000 Bbl. Tank Size)	2911 Petroleum and Coal Products	324 Wood Product Manufacturing; Petroleum and Coal Products Manufacturing
40301098	Petroleum Product Storage at Refineries, Fixed Roof Tanks (Varying Sizes), Specify Liquid: Breathing Loss (250000 Bbl. Tank Size)	5172 Wholesale Trade - Nondurable Goods	422 Wholesale Trade; Wholesale Trade, Nondurable Goods
40301099	Petroleum Product Storage at Refineries, Fixed Roof Tanks (Varying Sizes), Specify Liquid: Working Loss (Tank Diameter Independent)	2911 Petroleum and Coal Products	324 Wood Product Manufacturing; Petroleum and Coal Products Manufacturing
40301102	Petroleum Product Storage at Refineries, Floating Roof Tanks (Varying Sizes), Gasoline RVP 10: Standing Loss (67000 Bbl. Tank Size)	1422 Nonmetallic Minerals, Except Fuels	212 Mining; Mining (except Oil and Gas)
40301110	Petroleum Product Storage at Refineries, Floating Roof Tanks (Varying Sizes), Crude Oil RVP 5: Standing Loss (250000 Bbl. Tank Size)	2911 Petroleum and Coal Products	324 Wood Product Manufacturing; Petroleum and Coal Products Manufacturing
40301111	Petroleum Product Storage at Refineries, Floating Roof Tanks (Varying Sizes), Jet Naphtha (JP-4): Standing Loss (67000 Bbl. Tank Size)	2911 Petroleum and Coal Products	324 Wood Product Manufacturing; Petroleum and Coal Products Manufacturing
40301113	Petroleum Product Storage at Refineries, Floating Roof Tanks (Varying Sizes), Jet Kerosene: Standing Loss (67000 Bbl. Tank Size)	5171 Wholesale Trade - Nondurable Goods	422 Wholesale Trade; Wholesale Trade, Nondurable Goods
40301115	Petroleum Product Storage at Refineries, Floating Roof Tanks (Varying Sizes), Distillate Fuel #2: Standing Loss (67000 Bbl. Tank Size)	5171 Wholesale Trade - Nondurable Goods	422 Wholesale Trade; Wholesale Trade, Nondurable Goods
40301119	Petroleum Product Storage at Refineries, Floating Roof Tanks (Varying Sizes), Jet Kerosene: Withdrawal Loss	5171 Wholesale Trade - Nondurable Goods	422 Wholesale Trade; Wholesale Trade, Nondurable Goods
40301151	Petroleum Product Storage at Refineries, Floating Roof Tanks (Varying Sizes), Gasoline: Standing Loss - Internal	5171 Wholesale Trade - Nondurable Goods	422 Wholesale Trade; Wholesale Trade, Nondurable Goods

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40301202	Petroleum Product Storage at Refineries, Variable Vapor Space, Gasoline RVP 10: Filling Loss	5171 Wholesale Trade - Nondurable Goods	422 Wholesale Trade; Wholesale Trade, Nondurable Goods
40301206	Petroleum Product Storage at Refineries, Variable Vapor Space, Distillate Fuel #2: Filling Loss	5171 Wholesale Trade - Nondurable Goods	422 Wholesale Trade; Wholesale Trade, Nondurable Goods
40388801	Petroleum Product Storage at Refineries, Fugitive Emissions, Specify in Comments Field	2952 Petroleum and Coal Products	324 Wood Product Manufacturing; Petroleum and Coal Products Manufacturing
40400103	Petroleum Liquids Storage (non-Refinery), Bulk Terminals, Gasoline RVP 7: Breathing Loss (67000 Bbl. Capacity) - Fixed Roof Tank	5172 Wholesale Trade - Nondurable Goods	422 Wholesale Trade; Wholesale Trade, Nondurable Goods
40600131	Transportation and Marketing of Petroleum Products, Tank Cars and Trucks, Gasoline: Submerged Loading (Normal Service)	5171 Wholesale Trade - Nondurable Goods	422 Wholesale Trade; Wholesale Trade, Nondurable Goods
40600133	Transportation and Marketing of Petroleum Products, Tank Cars and Trucks, Jet Naphtha: Submerged Loading (Normal Service)	5171 Wholesale Trade - Nondurable Goods	422 Wholesale Trade; Wholesale Trade, Nondurable Goods
40600134	Transportation and Marketing of Petroleum Products, Tank Cars and Trucks, Kerosene: Submerged Loading (Normal Services)	5172 Wholesale Trade - Nondurable Goods	422 Wholesale Trade; Wholesale Trade, Nondurable Goods
40600135	Transportation and Marketing of Petroleum Products, Tank Cars and Trucks, Distillate Oil: Submerged Loading (Normal Service)	5171 Wholesale Trade - Nondurable Goods	422 Wholesale Trade; Wholesale Trade, Nondurable Goods
40600136	Transportation and Marketing of Petroleum Products, Tank Cars and Trucks, Gasoline: Splash Loading (Normal Service)	5171 Wholesale Trade - Nondurable Goods	422 Wholesale Trade; Wholesale Trade, Nondurable Goods
40600140	Transportation and Marketing of Petroleum Products, Tank Cars and Trucks, Distillate Oil: Splash Loading (Normal Service)	5171 Wholesale Trade - Nondurable Goods	422 Wholesale Trade; Wholesale Trade, Nondurable Goods
40600141	Transportation and Marketing of Petroleum Products, Tank Cars and Trucks, Gasoline: Submerged Loading (Balanced Service)	5172 Wholesale Trade - Nondurable Goods	422 Wholesale Trade; Wholesale Trade, Nondurable Goods
40600144	Transportation and Marketing of Petroleum Products, Tank Cars and Trucks, Gasoline: Splash Loading (Balanced Service)	5171 Wholesale Trade - Nondurable Goods	422 Wholesale Trade; Wholesale Trade, Nondurable Goods
40600147	Transportation and Marketing of Petroleum Products, Tank Cars and Trucks, Gasoline: Submerged Loading (Clean Tanks)	4952 Electric, Gas, and Sanitary Services	221 Utilities; Utilities

SCC	SCC Name	SIC	NAICS
40600233	Transportation and Marketing of Petroleum Products, Marine Vessels, Gasoline: Barge Loading - Cleaned and Vapor Free Tanks	5171 Wholesale Trade - Nondurable Goods	422 Wholesale Trade; Wholesale Trade, Nondurable Goods
40600240	Transportation and Marketing of Petroleum Products, Marine Vessels, Gasoline: Barge Loading - Average Tank Condition	5171 Wholesale Trade - Nondurable Goods	422 Wholesale Trade; Wholesale Trade, Nondurable Goods
40600249	Transportation and Marketing of Petroleum Products, Marine Vessels, Jet Fuel: Loading Barges	5171 Wholesale Trade - Nondurable Goods	422 Wholesale Trade; Wholesale Trade, Nondurable Goods
40600250	Transportation and Marketing of Petroleum Products, Marine Vessels, Kerosene: Loading Barges	5171 Wholesale Trade - Nondurable Goods	422 Wholesale Trade; Wholesale Trade, Nondurable Goods
40600251	Transportation and Marketing of Petroleum Products, Marine Vessels, Distillate Oil: Loading Barges	5171 Wholesale Trade - Nondurable Goods	422 Wholesale Trade; Wholesale Trade, Nondurable Goods
40600301	Transportation and Marketing of Petroleum Products, Gasoline Retail Operations - Stage I, Splash Filling	5171 Wholesale Trade - Nondurable Goods	422 Wholesale Trade; Wholesale Trade, Nondurable Goods
40600302	Transportation and Marketing of Petroleum Products, Gasoline Retail Operations - Stage I, Submerged Filling w/o Controls	9711 National Security and Intl. Affairs	928 Public Administration; National Security and International Affairs
40600306	Transportation and Marketing of Petroleum Products, Gasoline Retail Operations - Stage I, Balanced Submerged Filling	9711 National Security and Intl. Affairs	928 Public Administration; National Security and International Affairs
40600307	Transportation and Marketing of Petroleum Products, Gasoline Retail Operations - Stage I, Underground Tank Breathing and Emptying	3312 Primary Metal Industries	324 Wood Product Manufacturing; Petroleum and Coal Products Manufacturing
40600401	Transportation and Marketing of Petroleum Products, Filling Vehicle Gas Tanks - Stage II, Vapor Loss w/o Controls	3679 Electronic & Other Electric Equipment	334 Primary Metal Manufacturing; Computer and Electronic Product Manufacturing
40600402	Transportation and Marketing of Petroleum Products, Filling Vehicle Gas Tanks - Stage II, Liquid Spill Loss w/o Controls	4911 Electric, Gas, and Sanitary Services	221 Utilities; Utilities
40600403	Transportation and Marketing of Petroleum Products, Filling Vehicle Gas Tanks - Stage II, Vapor Loss w/o Controls	2631 Paper and Allied Products	322 Wood Product Manufacturing; Paper Manufacturing
40688801	Transportation and Marketing of Petroleum Products, Fugitive Emissions, Specify in Comments Field	4925 Electric, Gas, and Sanitary Services	221 Utilities; Utilities

SCC	SCC Name	SIC	NAICS
40688802	Transportation and Marketing of Petroleum Products, Fugitive Emissions, Specify in Comments Field	4925 Electric, Gas, and Sanitary Services	221 Utilities; Utilities
40688803	Transportation and Marketing of Petroleum Products, Fugitive Emissions, Specify in Comments Field	4925 Electric, Gas, and Sanitary Services	221 Utilities; Utilities
40688804	Transportation and Marketing of Petroleum Products, Fugitive Emissions, Specify in Comments Field	4925 Electric, Gas, and Sanitary Services	221 Utilities; Utilities
40700810	Organic Chemical Storage, Fixed Roof Tanks - Alcohols, Ethyl Alcohol: Working Loss	2099 Food and Kindred Products	311 Food Manufacturing; Food Manufacturing
40701612	Organic Chemical Storage, Fixed Roof Tanks - Alkanes (Paraffins), Naphtha: Working Loss	4925 Electric, Gas, and Sanitary Services	221 Utilities; Utilities
40703614	Organic Chemical Storage, Fixed Roof Tanks - Aromatics, Styrene: Working Loss	2851 Chemicals and Allied Products	325 Wood Product Manufacturing; Chemical Manufacturing
40703697	Organic Chemical Storage, Fixed Roof Tanks - Aromatics, Specify Aromatic: Breathing Loss	2851 Chemicals and Allied Products	325 Wood Product Manufacturing; Chemical Manufacturing
40706098	Organic Chemical Storage, Fixed Roof Tanks - Halogenated Organics, Specify Halogenated Organic: Working Loss	3479 Fabricated Metal Products	332 Primary Metal Manufacturing; Fabricated Metal Product Manufacturing
40799997	Organic Chemical Storage, Miscellaneous, Specify in Comments	3711 Transportation Equipment	336 Primary Metal Manufacturing; Transportation Equipment Manufacturing
49099999	Organic Solvent Evaporation, Miscellaneous Volatile Organic Compound Evaporation, Identify the Process and Solvent in Comments	4911 Electric, Gas, and Sanitary Services	221 Utilities; Utilities
50100101	Solid Waste Disposal - Government, Municipal Incineration, Starved Air: Multiple Chamber	4953 Electric, Gas, and Sanitary Services	562 Administrative and Support and Waste Management and Remediation Services; Waste Management and Remediation Services
50100201	Solid Waste Disposal - Government, Open Burning Dump, General Refuse	2892 Chemicals and Allied Products	325 Wood Product Manufacturing; Chemical Manufacturing
50100505	Solid Waste Disposal - Government, Other Incineration, Medical Waste Incinerator, unspecified type, Infectious wastes only	9711 National Security and Intl. Affairs	928 Public Administration; National Security and International Affairs

SCC	SCC Name	SIC	NAICS
50100701	Solid Waste Disposal - Government, Sewage Treatment, Entire Plant	4952 Electric, Gas, and Sanitary Services	221 Utilities; Utilities
50200101	Solid Waste Disposal - Commercial/Institutional, Incineration, Multiple Chamber	8063 Health Services	622 Health Care and Social Assistance; Hospitals
50200102	Solid Waste Disposal - Commercial/Institutional, Incineration, Single Chamber	4953 Electric, Gas, and Sanitary Services	562 Administrative and Support and Waste Management and Remediation Services; Waste Management and Remediation Services
50200103	Solid Waste Disposal - Commercial/Institutional, Incineration, Controlled Air	9711 National Security and Intl. Affairs	928 Public Administration; National Security and International Affairs
50200505	Solid Waste Disposal - Commercial/Institutional, Incineration: Special Purpose, Medical Waste Incinerator, unspecified type, Infectious wastes only	8062 Health Services	622 Health Care and Social Assistance; Hospitals
50200506	Solid Waste Disposal - Commercial/Institutional, Incineration: Special Purpose, Sludge	4952 Electric, Gas, and Sanitary Services	221 Utilities; Utilities
50200601	Solid Waste Disposal - Commercial/Institutional, Landfill Dump, Waste Gas Flares ** (Use 5-01-004-10)	4952 Electric, Gas, and Sanitary Services	221 Utilities; Utilities
50290005	Solid Waste Disposal - Commercial/Institutional, Auxillary Fuel/No Emissions, Distillate Oil	8221 Educational Services	611 Educational Services; Educational Services
50290006	Solid Waste Disposal - Commercial/Institutional, Auxillary Fuel/No Emissions, Natural Gas	3715 Transportation Equipment	336 Primary Metal Manufacturing; Transportation Equipment Manufacturing
50290010	Solid Waste Disposal - Commercial/Institutional, Auxillary Fuel/No Emissions, Liquified Petroleum Gas (LPG)	3715 Transportation Equipment	336 Primary Metal Manufacturing; Transportation Equipment Manufacturing
50300101	Solid Waste Disposal - Industrial, Incineration, Multiple Chamber	3585 Industrial Machinery and Equipment	333 Primary Metal Manufacturing; Machinery Manufacturing
50300102	Solid Waste Disposal - Industrial, Incineration, Single Chamber	2819 Chemicals and Allied Products	331 Primary Metal Manufacturing; Primary Metal Manufacturing
50300103	Solid Waste Disposal - Industrial, Incineration, Controlled Air	3711 Transportation Equipment	336 Primary Metal Manufacturing; Transportation Equipment Manufacturing

SCC	SCC Name	SIC	NAICS
50300105	Solid Waste Disposal - Industrial, Incineration, Conical Design (Tee Pee) Wood Refuse	2493 Lumber and Wood Products	321 Wood Product Manufacturing; Wood Product Manufacturing
50300106	Solid Waste Disposal - Industrial, Incineration, Trench Burner: Wood	2892 Chemicals and Allied Products	325 Wood Product Manufacturing; Chemical Manufacturing
50300506	Solid Waste Disposal - Industrial, Incineration, Sludge	2834 Chemicals and Allied Products	325 Wood Product Manufacturing; Chemical Manufacturing
50300701	Solid Waste Disposal - Industrial, Liquid Waste, General	2819 Chemicals and Allied Products	331 Primary Metal Manufacturing; Primary Metal Manufacturing
50390005	Solid Waste Disposal - Industrial, Auxillary Fuel/No Emissions, Distillate Oil	2892 Chemicals and Allied Products	325 Wood Product Manufacturing; Chemical Manufacturing
50390006	Solid Waste Disposal - Industrial, Auxillary Fuel/No Emissions, Natural Gas	3082 Rubber and Misc. Plastics Products	326 Wood Product Manufacturing; Plastics and Rubber Products Manufacturing